Motion in a Straight Line and Plane

Question1

A tube of length 1 m is filled completely with an ideal liquid of mass 2 M , and closed at both ends. The tube is rotated uniformly in horizontal plane about one of its ends. If the force exerted by the liquid at the other end is F then angular velocity of the tube is $\sqrt{\frac{\mathrm{F}}{\alpha \mathrm{M}}}$ in SI unit. The value of α is _____.

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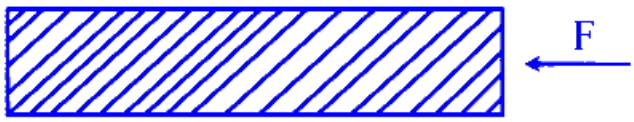
Answer: 1

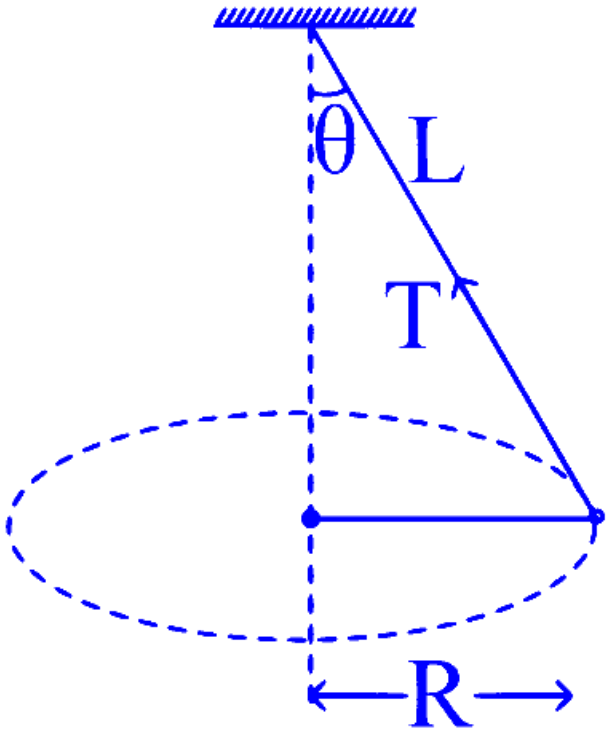
Solution:



$\mathrm{F}=2 \mathrm{M} \omega^2 \frac{\ell}{2}=\mathrm{Mw}^2 \ell$

$\omega=\sqrt{\frac{\mathrm{F}}{\mathrm{M} \ell}}$

Question2



A string of length L is fixed at one end and carries a mass of M at the other end. The mass makes $\left(\frac{3}{\pi}\right)$ rotations per second about the vertical axis passing through end of the string as shown. The tension in the string is _____ ML.

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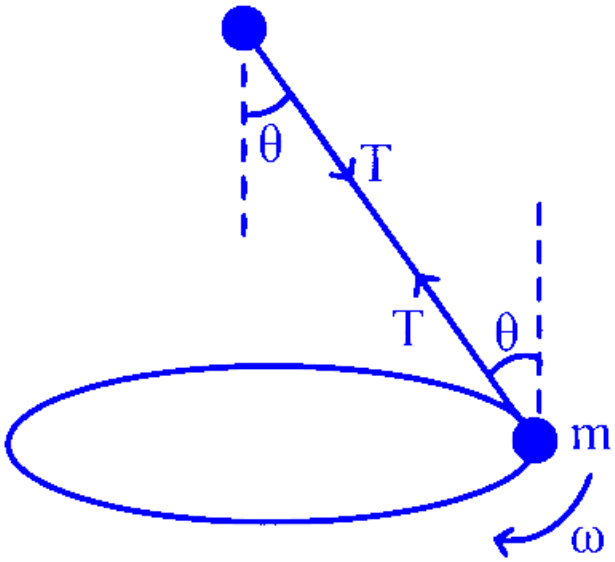
Answer: 36

Solution:



$\mathrm{T} \cos \theta = \mathrm{mg}$

$\mathrm{T} \sin \theta = \mathrm{M}\omega^2 \mathrm{R}$

Using equation (2)

$\mathrm{T} \sin \theta = \mathrm{M}\omega^2 (\mathrm{L} \sin \theta)$

$\mathrm{T} = \mathrm{M}\omega^2 \mathrm{L} = \mathrm{M}\left(\frac{3}{\pi} \times 2\pi\right)^2 \mathrm{L}$

$\mathrm{T} = 36\mathrm{ML}$

Question3

A particle of charge $1.6\mu\mathrm{C}$ and mass 16μ g is present in a strong magnetic field of 6.28 T . The particle is then fired perpendicular to magnetic field. The time required for the particle to return to original location for the first time is _____ s. $(\pi = 3.14)$

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Answer: 0

Solution:

To solve this problem, note that when a charged particle with mass m and charge q is fired perpendicular to a magnetic field of strength B , it undergoes uniform circular motion. The period (time to complete one full circle) is given by:

$T = \frac{2\pi m}{qB}$

Here's how to calculate it step by step:

Convert the given quantities to SI units:

Charge: $q = 1.6\,\mu\mathrm{C} = 1.6 \times 10^{-6}\,\mathrm{C}$

Mass: $m = 16\,\mu\mathrm{g} = 16 \times 10^{-9}\,\mathrm{kg}$

Magnetic field: $B = 6.28\,\mathrm{T}$

Write down the period formula:

$T = \frac{2\pi m}{qB}$

Substitute the values:

$T = \frac{2\pi \times (16 \times 10^{-9}\,\mathrm{kg})}{(1.6 \times 10^{-6}\,\mathrm{C})(6.28\,\mathrm{T})}$

Notice that $2\pi \approx 6.28$, which cancels with the given magnetic field value, simplifying the expression:

$T = \frac{6.28 \times 16 \times 10^{-9}}{1.6 \times 10^{-6} \times 6.28} = \frac{16 \times 10^{-9}}{1.6 \times 10^{-6}}$

Simplify the fraction:

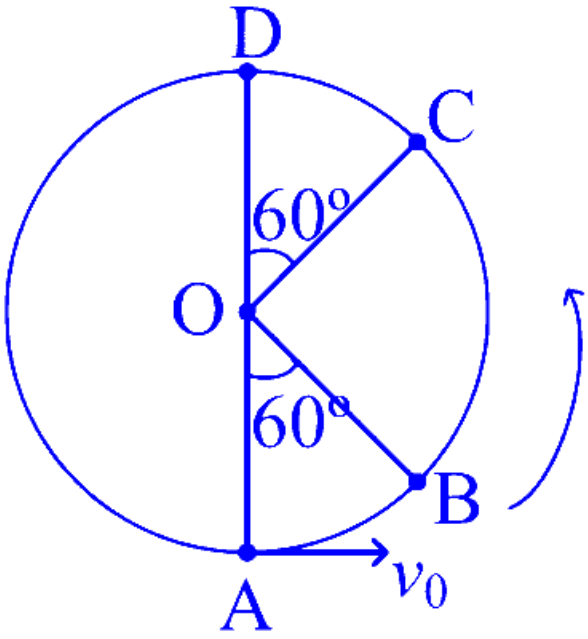
$T = \frac{16}{1.6} \times \frac{10^{-9}}{10^{-6}} = 10 \times 10^{-3} = 0.01\,\mathrm{s}$

Thus, the time required for the particle to return to its original location is:

$\boxed{0.01\,\mathrm{s}}$

Question4

A bob of mass m is suspended at a point O by a light string of length l and left to perform vertical motion (circular) as shown in figure. Initially, by applying horizontal velocity v_0 at the point ' A ', the string becomes slack when, the bob reaches at the point ' D '. The ratio of the kinetic energy of the bob at the points B and C is _____.



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Options:

A. 4

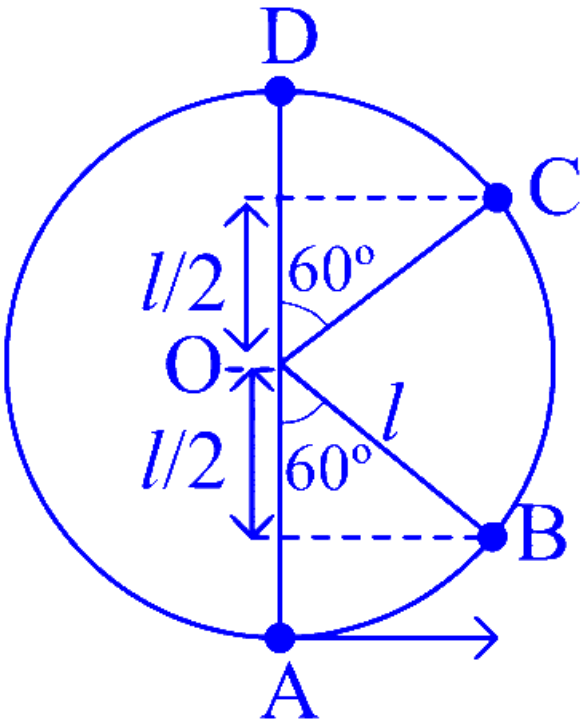
B. 1

C. 2

D. 3

Answer: C

Solution:



As the string becomes slack when the bob reaches at the point D so tension is zero at this point. And the bob just completes the circle.

We know, to complete a vertical loop of radius R, the minimum velocity required at the bottom of loop is $\sqrt{5gR}$.

So, $V_0 = \sqrt{5gl} = V_A$ (as R = l)

So, using energy conservation,

$\frac{1}{2}mv_A^2 = \frac{1}{2}mv_B^2 + mgh$

$\Rightarrow \frac{1}{2}m(5gl) = \frac{1}{2}mv_B^2 + mg\left(\frac{l}{2}\right)$

$\Rightarrow KE_B = \frac{mgl}{2}(5-1) = 2mgl$

For point C,

$\frac{1}{2}mv_A^2 = \frac{1}{2}mv_c^2 + mg\left(l + \frac{l}{2}\right)$

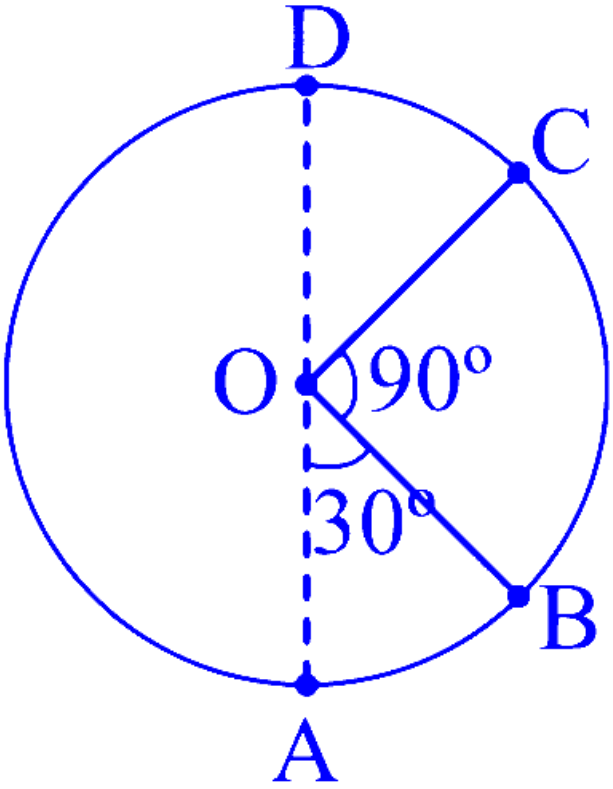
$\Rightarrow \frac{5}{2}mgl = KE_C + \frac{3mgl}{2}$

$KE_C = \frac{mgl}{2}(5-3) = mgl$

So, $\frac{KE_B}{KE_C} = \frac{2mgl}{mgl} = 2$

Question5

A body of mass 100 g is moving in circular path of radius 2 m on vertical plane as shown in figure. The velocity of the body at point A is $10\ \mathrm{m/s}$. The ratio of its kinetic energies at point B and C is :



(Take acceleration due to gravity as $10\ \mathrm{m/s^2}$)

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Options:

A. $\frac{3-\sqrt{2}}{2}$

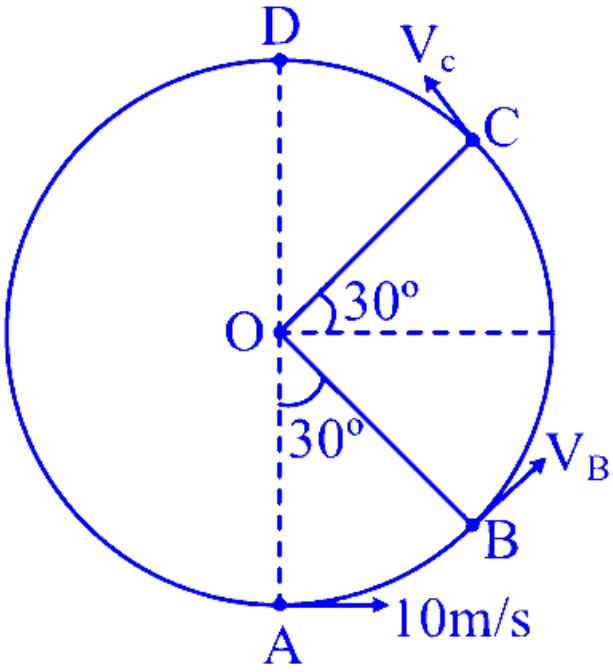
B. $\frac{2+\sqrt{3}}{3}$

C. $\frac{2+\sqrt{2}}{3}$

D. $\frac{3+\sqrt{3}}{2}$

Answer: D

Solution:



$\frac{1}{2}$ m $\times 100+0=\frac{1}{2}$mV_B^2+mg$\left(R-\frac{R\sqrt{3}}{2}\right)$

$100=V_B^2+2gR\left(1-\frac{\sqrt{3}}{2}\right]$

$V_B^2=100-20(2-\sqrt{3})$

$V_B^2=60+20\sqrt{3})$

$K_EE_B=\frac{1}{2}mV_B^2=\frac{m}{2}(60+20\sqrt{3})$

$\frac{1}{2}$ m$(100)=\frac{1}{2}$mV_C^2+mg$\left(\frac{3R}{2}\right)$

$100=V_C^2=60$

$V_C^2=40$

$K\cdot E_C=\frac{1}{2}mV_C^2=\frac{1}{2}$ m(40)

$K\cdot E_B=\frac{60+20\sqrt{3}}{40}=\frac{3}{2}+\frac{\sqrt{3}}{2}=\frac{3+\sqrt{3}}{2}$

Question6

A car of mass ' m ' moves on a banked road having radius ' r ' and banking angle θ. To avoid slipping from banked road, the maximum permissible speed of the car is v_0. The coefficient of friction μ between the wheels of the car and the banked road is

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Options:

A. $\mu=\frac{v_0^2+rg\tan\theta}{rg+v_0^2\tan\theta}$

B. $\mu=\frac{v_0^2-rg\tan\theta}{rg-v_0^2\tan\theta}$

C. $\mu = \frac{v_0^2 - rg\tan\theta}{rg + v_0^2\tan\theta}$

D. $\mu = \frac{v_o^2 + rg\tan\theta}{rg - v_o^2\tan\theta}$

Answer: C

Solution:

$N\cos\theta - \mu N\sin\theta = mg$

$N\sin\theta + \mu N\cos\theta = \frac{mv_0^2}{r}$

Dividing the second equation by the first gives

$\frac{v_0^2}{r} = \frac{g(\sin\theta + \mu\cos\theta)}{\cos\theta - \mu\sin\theta}$.

Multiplying both sides by $\cos\theta - \mu\sin\theta$ leads to

$\frac{v_0^2}{r}(\cos\theta - \mu\sin\theta) = g(\sin\theta + \mu\cos\theta)$.

Expanding and grouping the terms with μ:

$\frac{v_0^2}{r}\cos\theta - g\sin\theta = \mu\left(\frac{v_0^2}{r}\sin\theta + g\cos\theta\right)$.

Thus, solving for μ:

$\mu = \frac{\frac{v_0^2}{r}\cos\theta - g\sin\theta}{\frac{v_0^2}{r}\sin\theta + g\cos\theta}$.

Multiplying the numerator and the denominator by r gives

$\mu = \frac{v_0^2\cos\theta - rg\sin\theta}{v_0^2\sin\theta + rg\cos\theta}$.

Dividing both the numerator and denominator by $\cos\theta$ (assuming $\cos\theta \neq 0$):

$\mu = \frac{v_0^2 - rg\tan\theta}{v_0^2\tan\theta + rg}$.

This result matches the expression

$\mu = \frac{v_0^2 - rg\ \tan\theta}{rg + v_0^2\ \tan\theta}$.

Thus, the correct answer is:

Option C

Question7

A body of mass ‘m’ connected to a massless and unstretchable string goes in vertical circle of radius ‘R’ under gravity g. The other end of the string is fixed at the center of circle. If velocity at top of circular path is $n\sqrt{gR}$, where, n ≥ 1, then ratio of kinetic energy of the body at bottom to that at top of the circle is :

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Options:

A.

$\frac{n^2+4}{n^2}$

B.

$\frac{n+4}{n}$

C.

$\frac{n^2}{n^2+4}$

D.

$\frac{n}{n+4}$

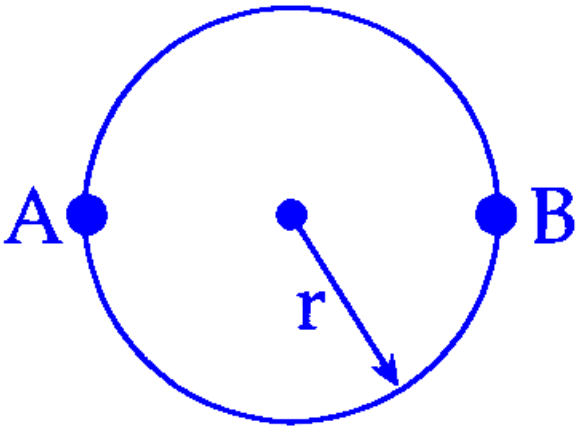
Answer: A

Solution:

$$\begin{aligned} \mathrm{V_{Top}} &= \sqrt{\mathrm{n^2gR}} \\ \mathrm{V_{Botom}} &= \sqrt{\mathrm{n^2gR + 4gR}} \\ \mathrm{Ratio} &= \frac{\mathrm{n^2+4}}{\mathrm{n^2}} \end{aligned}$$

Question8

A sportsman runs around a circular track of radius r such that he traverses the path $ABAB$. The distance travelled and displacement, respectively, are



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Options:

A. $\pi r, 3r$

B. $2\mathrm{r}, 3\pi\mathrm{r}$

C. $3\pi\mathrm{r}, 2\mathrm{r}$

D. $3\pi r, \pi r$

Answer: C

Solution:

To determine the distance traveled and displacement of a sportsman running around a circular track, we begin by analyzing the path described as $A \to B \to A \to B$.

Displacement:

The displacement is the straight line distance from the initial point to the final point. In this case, the sportsman completes one full circle (from A back to A) and then continues to point B (which is opposite point A on the circle). Therefore, the displacement is the diameter of the circle:

Displacement $= 2r$

Distance:

The distance is the total path length traveled by the sportsman. Starting at A, he completes one full circle back to A, which has a circumference of:

$2\pi r$

He then runs half the circle from A to B, which is another:

$\frac{1}{2} \times 2\pi r = \pi r$

Thus, the total distance is the circumference of the full circle plus half of another circle:

Distance $= 2\pi r + \pi r = 3\pi r$

In summary, the distance traveled by the sportsman is $3\pi r$ and the displacement is $2r$.

Question9

A wheel is rolling on a plane surface. The speed of a particle on the highest point of the rim is $8\ \mathrm{m/s}$. The speed of the particle on the rim of the wheel at the same level as the centre of wheel, will be :

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Options:

A. $4\sqrt{2}\ \mathrm{m/s}$

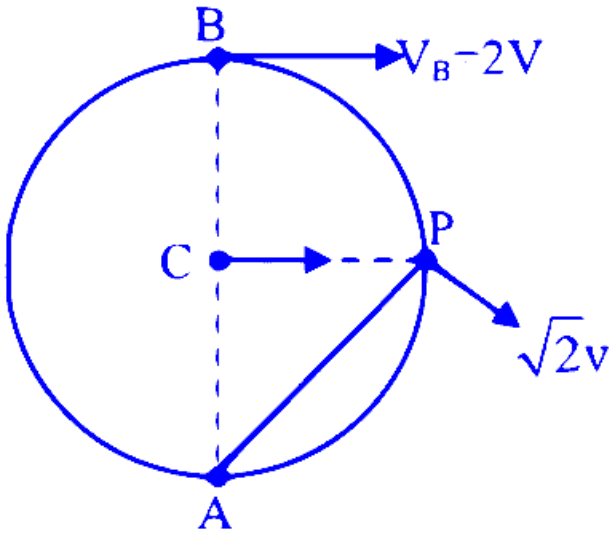
B. $8\ \mathrm{m/s}$

C. $4\ \mathrm{m/s}$

D. $8\sqrt{2}\ \mathrm{m/s}$

Answer: A

Solution:



If $V_B = 2V$

Point A is instantaneous center of rotation

Given $V_B = 8\ \mathrm{m/s}$

$\mathrm{V} = 4\ \mathrm{m/s}$
$\mathrm{V_P} = \sqrt{2}\mathrm{v} \Rightarrow V_\mathrm{p} = 4\sqrt{2}\ \mathrm{m/s}$
correct(1)

Question10

A particle is projected at an angle of 30° from horizontal at a speed of $60\ \mathrm{m/s}$. The height traversed by the particle in the first second is $\mathrm{h_0}$ and height traversed in the last second, before it reaches the maximum height, is h_1. The ratio $h_0 : h_1$ is _____.

[Take, $\mathrm{g} = 10\ \mathrm{m/s^2}$]

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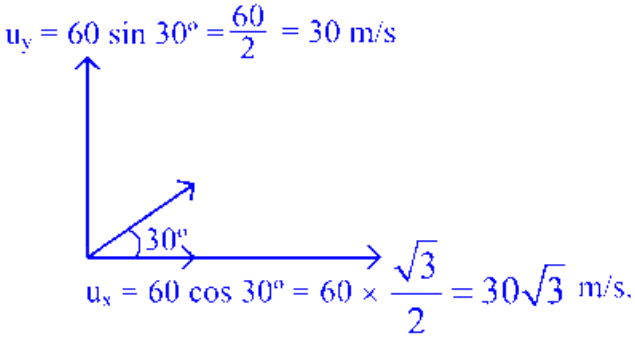
Answer: 5

Solution:



Time to reach max. height,

$v_y = u_y - gt$

$O = 30 - 10t \Rightarrow t = 3s$

We know, $S_n = u + \frac{a}{2}(2n-1)$

So, $h_0 = S_1 = 30 - \frac{10}{2}(2 \times 1 - 1) = 30 - 5 = 25$ m

and $h_1 = Sw_3 = 30 - \frac{10}{2}(2 \times 3 - 1) = 30 - 25 = 5$

Hence, $\frac{h_0}{h_1} = \frac{25}{5} = 5$

Question11

The maximum speed of a boat in still water is 27 km/h. Now this boat is moving downstream in a river flowing at 9 km/h. A man in the boat throws a ball vertically upwards with speed of 10 m/s. Range of the ball as observed by an observer at rest on the bank is _____ cm. (Take $g = 10$ m/s^2)

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Answer: 2000

Solution:

The first step is to determine the horizontal velocity of the ball as seen by an observer on the bank.

The velocity of the boat in still water is 27 km/h. Since the boat is moving downstream and the river flows at 9 km/h, the actual speed of the boat relative to the bank becomes:

$v_{\text{boat}} = 27 + 9 = 36$ km/h

Convert this speed from km/h to m/s by using the conversion factor 1 km/h $= \frac{5}{18}$ m/s:

$v_{\text{boat}} = 36 \times \frac{5}{18} = 10$ m/s

This is also the horizontal velocity of the ball as seen by the observer on the bank.

Next, calculate the time the ball spends in the air. The initial vertical velocity of the ball is 10 m/s. The time to reach the maximum height t_{up} is given by:

$t_{\text{up}} = \frac{v_{\text{initial}}}{g} = \frac{10}{10} = 1$ s

The total time of flight t_{total} is twice the time to reach the maximum height:

$t_{\text{total}} = 2 \times 1 = 2$ s

The horizontal range R of the ball is the horizontal velocity multiplied by the total time of flight:

$R = v_{\text{horizontal}} \times t_{\text{total}} = 10 \times 2 = 20$ m

Finally, convert this range into centimeters:

$R = 20 \times 100 = 2000$ cm

Thus, the range of the ball as observed by an observer at rest on the bank is 2000 cm.

Question12

A ball of mass 100 g is projected with velocity $20\ \mathrm{m/s}$ at 60° with horizontal. The decrease in kinetic energy of the ball during the motion from point of projection to highest point is

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Options:

A. 20 J

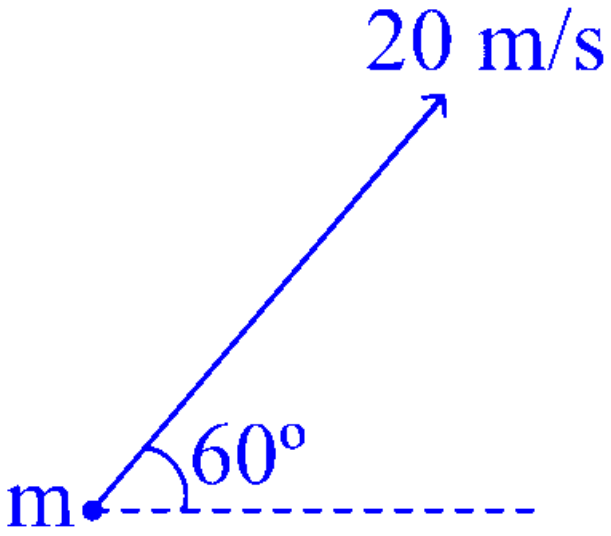
B. 5 J

C. 15 J

D. zero

Answer: C

Solution:



$$k_i = \frac{1}{2}mv^2$$
$$k_f = \frac{1}{2}\,m(v\cos 60^\circ)^2 = \frac{1}{8}mv^2$$
$$\Delta k = k_i - k_f = \frac{3}{8}mv^2 = \frac{3}{8}\times 0.1 \times 400 = 15\ \mathrm{J}$$

Question13

An object of mass ' m ' is projected from origin in a vertical xy plane at an angle 45° with the $x-$ axis with an initial velocity v_0. The magnitude and direction of the angular momentum of the object with respect to origin, when it reaches at the maximum height, will be [g is acceleration due to gravity]

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Options:

A. $\frac{mv_o^3}{2\sqrt{2}g}$ along negative z-axis

B. $\frac{mv_o^3}{2\sqrt{2}g}$ along positive z-axis

C. $\frac{mv_o^3}{4\sqrt{2}g}$ along positive z-axis

D. $\frac{mv_o^3}{4\sqrt{2}g}$ along negative z-axis

Answer: D

Solution:

$\vec{v_0} = \frac{v_0}{\sqrt{2}}\,\hat{i} + \frac{v_0}{\sqrt{2}}\,\hat{j}.$

At maximum height, the vertical component of the velocity becomes zero. Setting the vertical velocity to zero:

$\frac{v_0}{\sqrt{2}} - g\,t = 0 \quad \Longrightarrow \quad t = \frac{v_0}{g\sqrt{2}}.$

The coordinates at this time are:

$x = \frac{v_0}{\sqrt{2}}\,t = \frac{v_0}{\sqrt{2}} \cdot \frac{v_0}{g\sqrt{2}} = \frac{v_0^2}{2g},$

$y = \frac{v_0}{\sqrt{2}}\,t - \frac{1}{2}g\,t^2 = \frac{v_0^2}{2g} - \frac{1}{2}g\,\frac{v_0^2}{2g^2} = \frac{v_0^2}{2g} - \frac{v_0^2}{4g} = \frac{v_0^2}{4g}.$

Thus, the position vector at maximum height is:

$\vec{r} = \frac{v_0^2}{2g}\,\hat{i} + \frac{v_0^2}{4g}\,\hat{j}.$

At maximum height, the only nonzero component of velocity is the horizontal one:

$\vec{v} = \frac{v_0}{\sqrt{2}}\,\hat{i}.$

The angular momentum about the origin is given by:

$\vec{L} = m\,\vec{r} \times \vec{v}.$

Writing out the cross product:

$\vec{r} \times \vec{v} = \left(\frac{v_0^2}{2g}\,\hat{i} + \frac{v_0^2}{4g}\,\hat{j}\right) \times \frac{v_0}{\sqrt{2}}\,\hat{i}.$

Since the cross product of $\hat{i}$ with itself is zero and:

$\hat{j} \times \hat{i} = -\hat{k},$

we have:

$\vec{r} \times \vec{v} = \frac{v_0^2}{4g} \cdot \frac{v_0}{\sqrt{2}}\,(-\hat{k}) = -\frac{v_0^3}{4\sqrt{2}g}\,\hat{k}.$

Thus, the angular momentum is:

$\vec{L} = -\frac{m\,v_0^3}{4\sqrt{2}g}\,\hat{k}.$

This means the magnitude is:

$\frac{m v_0^3}{4\sqrt{2}g}$,

and its direction is along the negative $\hat{k}$ (or negative z-axis).

Question14

The position vector of a moving body at any instant of time is given as $\vec{r} = \left(5t^2\hat{i} - 5t\hat{j}\right)m$. The magnitude and direction of velocity at $t = 2s$ is,

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Options:

A. $5\sqrt{17}$ m/s, making an angle of $\tan^{-1} 4$ with - ve Y axis

B. $5\sqrt{15}$ m/s, making an angle of $\tan^{-1} 4$ with + ve X axis

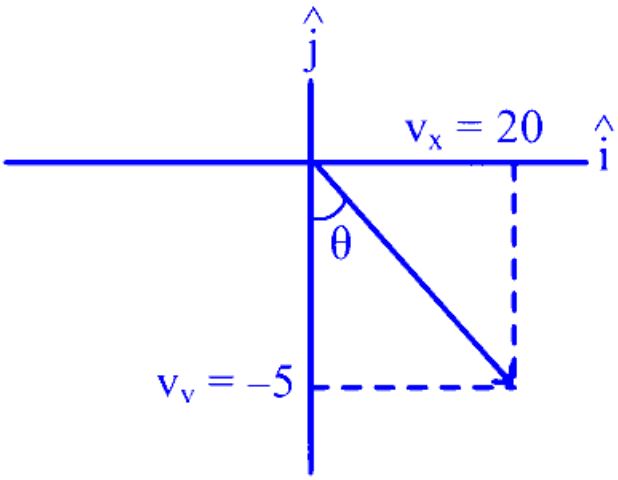
C. $5\sqrt{17}$ m/s, making an angle of $\tan^{-1} 4$ with + ve X axis

D. $5\sqrt{15}$ m/s, making an angle of $\tan^{-1} 4$ with $-$ ve Y axis

Answer: A

Solution:

$\vec{r} = 5t^2\hat{i} - 5\hat{t}$
$\vec{v} = 10t\hat{i} - 5\hat{j}$
$\vec{v} = 20\hat{i} - 5\hat{j}$ at $t = 2$sec



$\tan\theta = \frac{20}{5} = 4$
$\theta = \tan^{-1} 4$
From-veY-axis

Question15

Two projectiles are fired with same initial speed from same point on ground at angles of $(45^\circ - \alpha)$ and $(45^\circ + \alpha)$, respectively, with the horizontal direction. The ratio of their maximum heights attained is :

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Options:

A.

$\frac{1+\sin\alpha}{1-\sin\alpha}$

B.

$\frac{1+\sin 2\alpha}{1-\sin 2\alpha}$

C.

$\frac{1-\tan\alpha}{1+\tan\alpha}$

D.

$\frac{1-\sin 2\alpha}{1+\sin 2\alpha}$

Answer: D

Solution:

$$\mathrm{H_{Max}} = \frac{(\mathrm{u}\sin\theta)^2}{2\,\mathrm{g}}$$

$$\frac{(\mathrm{H_{max}})_1}{(\mathrm{H_{max}})_2} = \frac{\mathrm{u}^2\sin^2(45-\alpha)}{\mathrm{u}^2\sin^2(45+\alpha)}$$

$$= \frac{\left(\frac{1}{\sqrt{2}}\cos\alpha - \frac{1}{\sqrt{2}}\sin\alpha\right)^2}{\left(\frac{1}{\sqrt{2}}\cos\alpha + \frac{1}{\sqrt{2}}\sin\alpha\right)^2}$$

$$= \frac{1-\sin 2\alpha}{1+\sin 2\alpha}$$

Question16

A river is flowing from west to east direction with speed of $9\ \mathrm{km\ h^{-1}}$. If a boat capable of moving at a maximum speed of $27\ \mathrm{km\ h^{-1}}$ in still water, crosses the river in half a minute, while moving with maximum speed at an angle of 150° to direction of river flow, then the width of the river is :

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Options:

A. 112.5 m

B. 75 m

C. 300 m

D. $112.5 \times \sqrt{3}$ m

Answer: A

Solution:

$\therefore V_{\perp} =$ river flow $= 27 \times \cos 60^{\circ} = \frac{27}{2}$ km/hr

Time taken $= 30$sec.

$\therefore S = Vt = \frac{27}{2} \times \frac{5}{18} \times 30$ m $= 112.5$ m

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Question17

The angle of projection of a particle is measured from the vertical axis as ϕ and the maximum height reached by the particle is h_m. Here h_m as function of ϕ can be presented as

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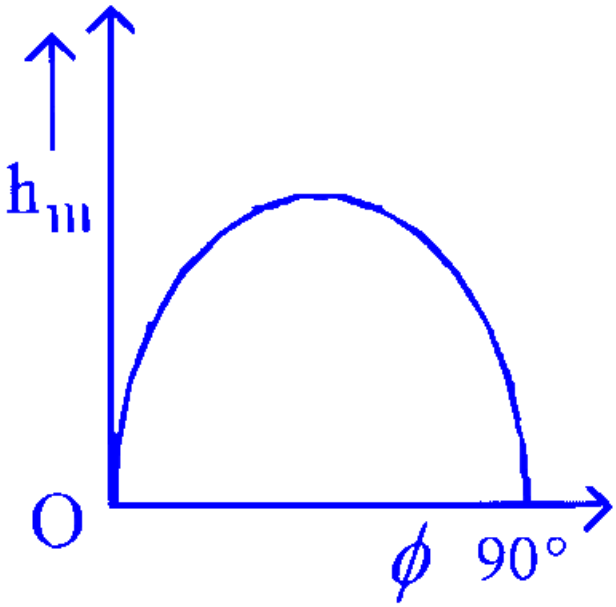
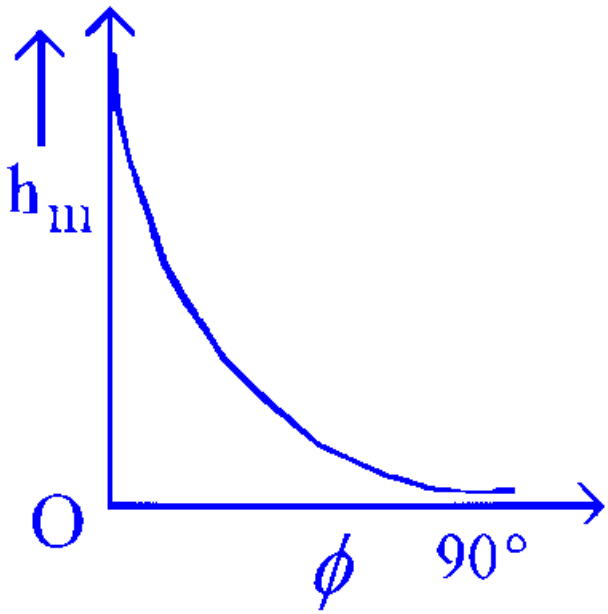
Options:

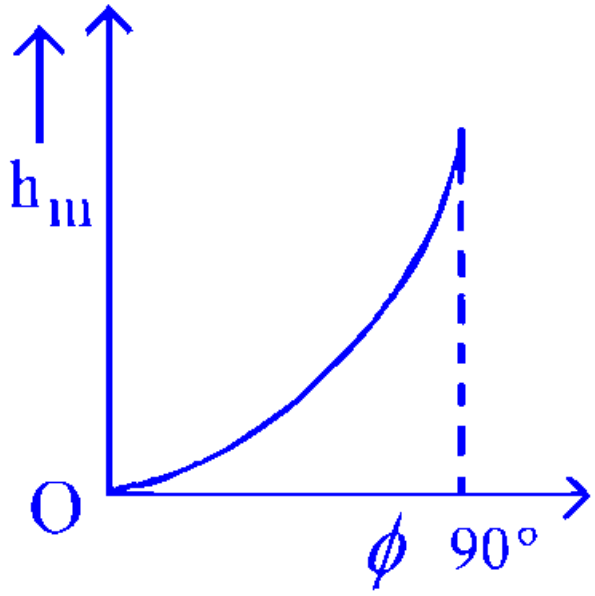
A.



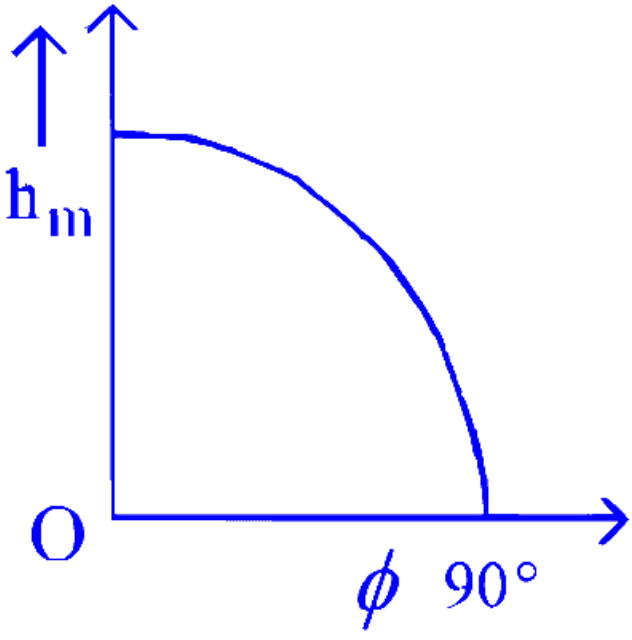
B.



C.

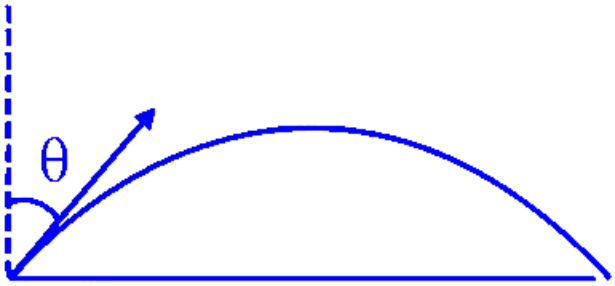


D.



Answer: D

Solution:



$\mathrm{H}_{\max }=\frac{\mathrm{u}^2 \cos ^2 \phi}{2 \mathrm{~g}}$

Question18

A particle is projected with velocity u so that its horizontal range is three times the maximum height attained by it. The horizontal range of the projectile is given as $\frac{nu^2}{25g}$, where value of n is: (Given, ' g ' is the acceleration due to gravity.)

JEE Main 2025 (Online) 3rd April Evening Shift

Options:

A. 6

B. 12

C. 18

D. 24

Answer: D

Solution:

Given that the horizontal range of a projectile is three times its maximum height, we need to determine the value of n in the expression for the range $\frac{nu^2}{25g}$.

Let's start by setting up the equations for the range and maximum height of a projectile.

The formula for the range R is:

$R=\frac{u^2 \sin 2\theta}{g}$

The formula for the maximum height $H_{\max}$ is:

$H_{\max }=\frac{u^2 \sin ^2 \theta}{2g}$

According to the problem, the range R is three times the maximum height $H_{\max}$:

$R=3H_{\max}$

Substituting the formulas for R and $H_{\max}$ into this condition gives:

$\frac{u^2 \sin 2\theta}{g} = 3 \cdot \frac{u^2 \sin^2 \theta}{2g}$

Simplifying this equation, we get:

$2 \sin \theta \cos \theta = \frac{3}{2} \sin^2 \theta$

Using the identity $\sin 2\theta = 2 \sin \theta \cos \theta$, we can rewrite:

$2 \sin \theta \cos \theta = \sin 2\theta$

This gives us:

$\sin 2\theta = \frac{3}{2} \sin^2 \theta$

Dividing both sides by $\sin \theta$, assuming $\sin \theta \neq 0$, we have:

$2 \cos \theta = \frac{3}{2} \sin \theta$

Rearranging the terms to solve for $\tan \theta$, we get:

$\tan \theta = \frac{4}{3}$

Thus, the angle θ where $\tan \theta = \frac{4}{3}$ corresponds to $\theta = 53^\circ$.

Now, substituting back into the range formula:

$R = \frac{u^2 \cdot 2 \cdot \frac{3}{5} \cdot \frac{4}{5}}{g}$

The calculation yields:

$R = \frac{24u^2}{25g}$

Therefore, the value of n in the expression $\frac{nu^2}{25g}$ is $n = 24$.

Question19

Two projectiles are fired from ground with same initial speeds from same point at angles $(45^\circ + \alpha)$ and $(45^\circ - \alpha)$ with horizontal direction. The ratio of their times of flights is

JEE Main 2025 (Online) 7th April Morning Shift

Options:

A. $\frac{1+\tan \alpha}{1-\tan \alpha}$

B. $\frac{1+\sin 2\alpha}{1-\sin 2\alpha}$

C. $\frac{1-\tan \alpha}{1+\tan \alpha}$

D. 1

Answer: A

Solution:

To find the ratio of the times of flight for two projectiles fired from the ground with the same initial speed but at different angles, we follow these steps:

Projectile Angles:

The first projectile is launched at an angle $\theta_1 = 45^\circ + \alpha$.

The second projectile is launched at an angle $\theta_2 = 45^\circ - \alpha$.

Time of Flight Formula:

The time of flight T for a projectile is given by:

$T = \frac{2v \sin \theta}{g}$

where v is the initial speed and g is the acceleration due to gravity.

Ratio of Times of Flight:

The ratio of the times of flights $\frac{T_1}{T_2}$ can be determined as follows:

$\frac{T_1}{T_2} = \frac{\sin(45^\circ + \alpha)}{\sin(45^\circ - \alpha)}$

Applying Trigonometric Identities:

Use the sine addition and subtraction formulas:

$\sin(45^\circ + \alpha) = \frac{1}{\sqrt{2}}(\cos \alpha + \sin \alpha)$

$\sin(45^\circ - \alpha) = \frac{1}{\sqrt{2}}(\cos \alpha - \sin \alpha)$

Simplifying the Ratio:

Substitute the expressions for $\sin(45^\circ + \alpha)$ and $\sin(45^\circ - \alpha)$ into the ratio:

$\frac{T_1}{T_2} = \frac{\frac{1}{\sqrt{2}}(\cos \alpha + \sin \alpha)}{\frac{1}{\sqrt{2}}(\cos \alpha - \sin \alpha)} = \frac{\cos \alpha + \sin \alpha}{\cos \alpha - \sin \alpha}$

Factor out the trigonometric functions to express in terms of tangent:

$\frac{T_1}{T_2} = \frac{1 + \tan \alpha}{1 - \tan \alpha}$

Therefore, the ratio of the times of flights for the two projectiles is $\frac{1 + \tan \alpha}{1 - \tan \alpha}$.

Question20

A helicopter flying horizontally with a speed of 360 km/h at an altitude of 2 km, drops an object at an instant. The object hits the ground at a point O, 20 s after it is dropped. Displacement of 'O' from the position of helicopter where the object was released is :

(use acceleration due to gravity g = 10 m/s^2 and neglect air resistance)

JEE Main 2025 (Online) 7th April Evening Shift

Options:

A.

7.2 km

B.

$2\sqrt{5}$ km

C.

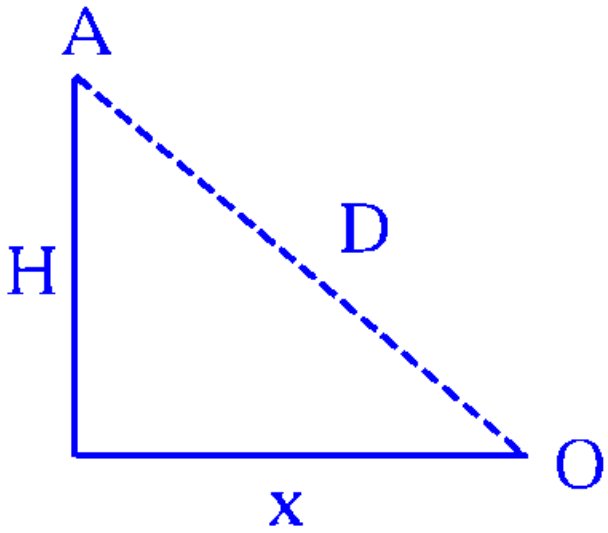
$2\sqrt{2}$ km

D.

4 km

Answer: C

Solution:



$u = 360 \times \frac{5}{18} = 100 \text{ m/s}$
$\text{x} = \text{u} \times \text{t} = 2 \times 10^3 \text{ m}$
$\text{t} = \sqrt{\frac{2\text{H}}{\text{g}}} \Rightarrow \text{H} = \frac{\text{t}^2\,\text{g}}{2}$
$\text{H} = \frac{400 \times 10}{2}$
$\text{H} = 2000 \text{ m}$
$\text{D} = \sqrt{\text{x}^2 + \text{H}^2}$
$\text{D} = 2\sqrt{2} \text{ km}$

Question21

Two balls with same mass and initial velocity, are projected at different angles in such a way that maximum height reached by first ball is 8 times higher than that of the second ball. T_1 and T_2 are the total flying times of first and second ball, respectively, then the ratio of T_1 and T_2 is

JEE Main 2025 (Online) 8th April Evening Shift

Options:

A.

2 : 1

B.

$\sqrt{2}:1$

C.

$2\sqrt{2}:1$

D.

4 : 1

Answer: C

Solution:

Given that the maximum height reached by the first ball is 8 times that of the second ball:

$(H_{\max})_1 = 8 \times (H_{\max})_2$

We can relate this to the initial velocities and angles using the formula for maximum height:

$\frac{u^2 \sin^2 \theta_1}{2g} = 8 \times \frac{u^2 \sin^2 \theta_2}{2g}$

Simplifying, we find:

$\sin \theta_1 = 2\sqrt{2} \sin \theta_2$

Now, the ratio of the total flying times T_1 and T_2 is given by:

$\frac{T_1}{T_2} = \frac{2u \sin \theta_1 / g}{2u \sin \theta_2 / g} = \frac{\sin \theta_1}{\sin \theta_2} = 2\sqrt{2}$

Thus, the ratio of T_1 to T_2 is $2\sqrt{2}:1$.

Question22

Two cars P and Q are moving on a road in the same direction. Acceleration of car P increases linearly with time whereas car Q moves with a constant acceleration. Both cars cross each other at time t = 0, for the first time. The maximum possible number of crossing(s) (including the crossing at t = 0) is _____.

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Answer: 3

Solution:

Here, we will use the concept of relative motion.

Let initial (at $t = 0$) position of both cars is x = 0 (As they cross each other at t = 0 for Ist time)

given : For P

$a_P \propto t$

For Q,

$a_Q = a'$ (Let) (constant)

$\Rightarrow a_{p^{(t)}} = kt$ where, k = constant

$\Rightarrow \frac{dv_p(t)}{dt} = kt$ (as $a = \frac{dv}{dt}$)

$\Rightarrow \int_0^{v_p(t)} dv_p(t) = \int_0^t ktdt$ [let p and Q both starts from rest]

$\Rightarrow v_p(t) = \frac{kt^2}{2}$

$\Rightarrow \frac{dx_p(t)}{dt} = \frac{kt^2}{2}$ [As $v = \frac{dx}{dt}$]

$\Rightarrow \int_0^{x_p(t)} dx_{p(t)} = \int_0^t \frac{kt^2}{2} dt$

$\Rightarrow x_p(t) = \frac{kt^3}{6}$ .... (1)

Now, for Q,

$x_Q(t) = \frac{1}{2}a^1t^2$ .... (2) [using Newton's 2nd equation of motion]

So, relative position of P w.r.t. Q,

$x_{PQ^{(t)}} = x_p(t) - x_Q(t)$

$\Rightarrow x_{PQ^{(t)}} = \frac{kt^3}{6} - \frac{1}{2}a^1t^2$ (From (1) and (2))

When both cars cross each other, $X_{PQ} = O$

As $X_{PQ}(t)$ is a cubic polynomial, so it has maximum 3 roots.

Hence, the maximum number of crossing = 3

Question23

A person travelling on a straight line moves with a uniform velocity v_1 for a distance x and with a uniform velocity v_2 for the next $\frac{3}{2}x$ distance. The average velocity in this motion is $\frac{50}{7}$ m/s. If v_1 is 5 m/s then $v_2 =$ _____ m/s.

JEE Main 2025 (Online) 2nd April Morning Shift

Answer: 10

Solution:

To find the average velocity given the motion of a person traveling along a straight line with two different velocities, we start by calculating the average velocity (v_{avg}) using the total distance traveled divided by the total time taken.

The distances and velocities are given as follows:

Distance x at velocity $v_1 = 5$ m/s

Distance $\frac{3}{2}x$ at velocity v_2

The formula for average velocity is:

$v_{\text{avg}} = \frac{\text{Total Distance}}{\text{Total Time}}$

Given:

$v_{\text{avg}} = \frac{50}{7}$ m/s

The total distance traveled is:

$x + \frac{3x}{2} = \frac{5x}{2}$

The time taken to cover each segment is given by:

Time for x: $t_1 = \frac{x}{v_1} = \frac{x}{5}$

Time for $\frac{3x}{2}$: $t_2 = \frac{\frac{3x}{2}}{v_2} = \frac{3x}{2v_2}$

Now, using the formula for average velocity:

$\frac{50}{7} = \frac{\frac{5x}{2}}{\frac{x}{5} + \frac{3x}{2v_2}}$

Simplifying the equation:

$\frac{50}{7} = \frac{5/2}{\frac{1}{5} + \frac{3}{2v_2}}$

Cross-multiplying gives:

$\frac{1}{5} + \frac{3}{2v_2} = \frac{7}{20}$

Solving for $\frac{3}{2v_2}$:

$\frac{3}{2v_2} = \frac{7}{20} - \frac{1}{5} = \frac{7-4}{20} = \frac{3}{20}$

Finally, solving for v_2:

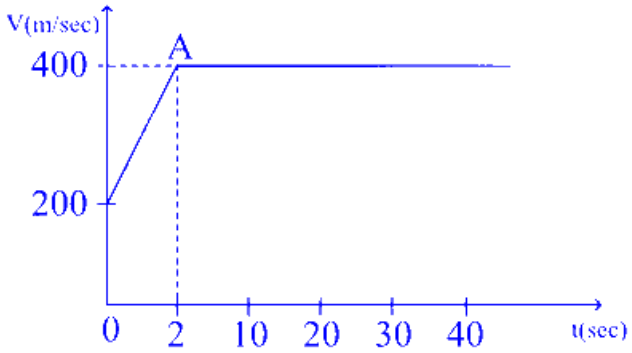
$\frac{3}{2v_2} = \frac{3}{20}$

$v_2 = 10\,\text{m/s}$

Thus, the value of v_2 is 10 m/s.

Question24

The motion of an airplane is represented by velocity-time graph as shown below. The distance covered by airplane in the first 30.5 second is_____ km .



JEE Main 2025 (Online) 23rd January Morning Shift

Options:

A. 12

B. 6

C. 3

D. 9

Answer: A

Solution:

The distance covered by the airplane in the first 30.5 seconds can be determined by calculating the area under the velocity-time graph.

The formula for distance in this scenario is:

Distance = Area under the graph

Calculating the individual areas:

$300\,\text{m/s} \times 2\,\text{s} = 600\,\text{m}$

$400\,\text{m/s} \times 28.5\,\text{s} = 11400\,\text{m}$

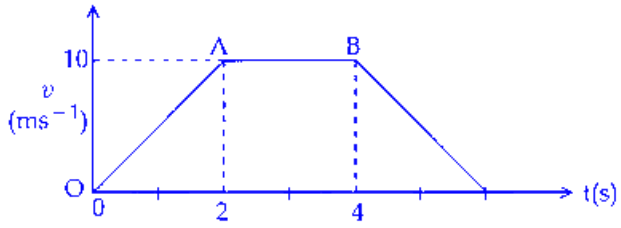
Adding these values gives the total distance:

Total distance $= 600\,\text{m} + 11400\,\text{m} = 12000\,\text{m}$

Thus, the distance covered by the airplane in the first 30.5 seconds is 12000 m, which is equivalent to 12 km.

Question25

The velocity-time graph of an object moving along a straight line is shown in the figure. What is the distance covered by the object between $t = 0$ to $t = 4s$?



JEE Main 2025 (Online) 28th January Evening Shift

Options:

A.

11 m

B.

30 m

C.

13 m

D.

10 m

Answer: B

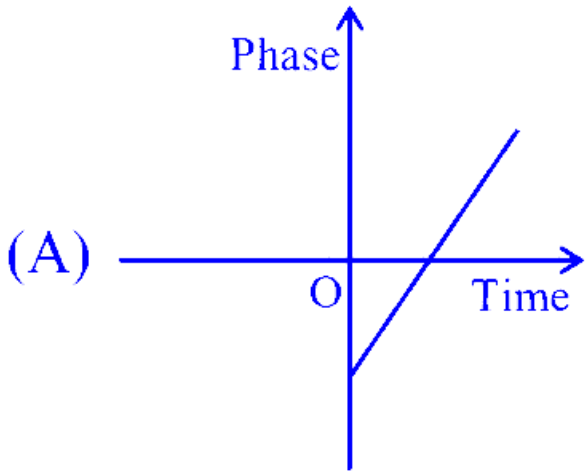
Solution:

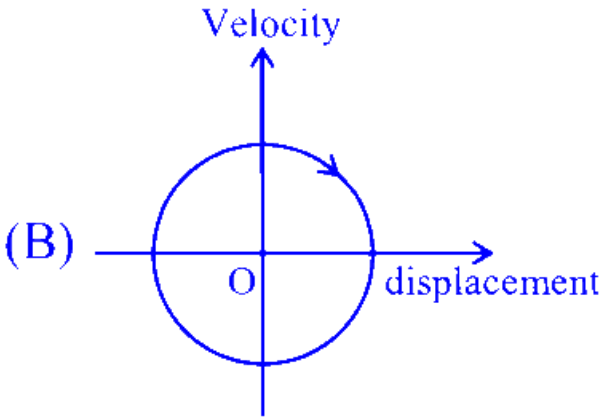
$$\text{Distance} = \text{Area under vv/s t graph}$$

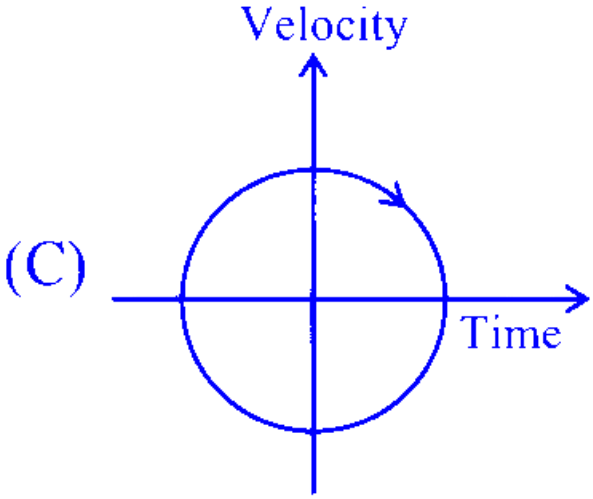
$$\text{Distance} = \frac{1}{2} \times 2 \times 10 + 2 \times 10 = 30 \text{ m}$$

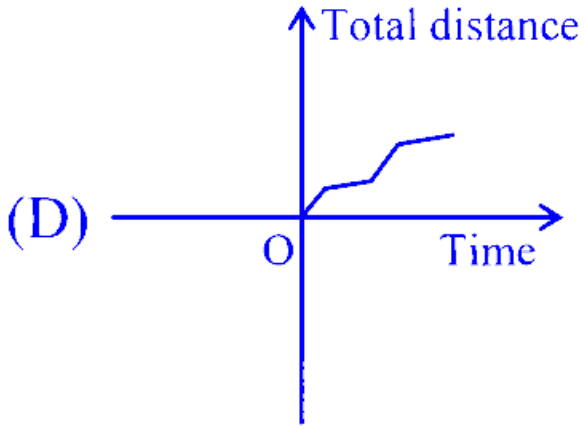
Question26

Which of the following curves possibly represent one-dimensional motion of a particle?









Choose the correct answer from the options given below :

JEE Main 2025 (Online) 3rd April Morning Shift

Options:

A. A, B and C only

B. A, C and D only

C. A, B and D only

D. A and B only

Answer: C

Solution:

For option (A)

$\phi = \mathrm{kt} + \mathrm{C}$ it can be 1 D motion

eg $\rightarrow \mathrm{x} = \mathrm{A}\sin\phi$(SHM)

For option (B)

$\mathrm{v}^2 + \mathrm{x}^2 =$ constant yes 1D

For option (C)

time can't be negative Not possible

For option (D)

Possible

A, B & D only

Question27

A particle moves along the x-axis and has its displacement x varying with time t according to the equation:

$x = c_0 \left(t^2 - 2\right) + c(t - 2)^2$

where c_0 and c are constants of appropriate dimensions.

Then, which of the following statements is correct?

JEE Main 2025 (Online) 3rd April Evening Shift

Options:

A. the acceleration of the particle is $2\left(c + c_0\right)$

B. the acceleration of the particle is $2c_0$

C. the acceleration of the particle is 2 c

D. the initial velocity of the particle is $4c$

Answer: A

Solution:

To determine the acceleration of the particle, we start by differentiating the displacement function with respect to time t.

The displacement of the particle is given by:

$x = c_0(t^2 - 2) + c(t - 2)^2$

First, compute the velocity v by differentiating x with respect to t:

$v = \frac{dx}{dt} = \frac{d}{dt}[c_0(t^2 - 2) + c(t - 2)^2]$

This gives:

$v = 2c_0t + 2c(t - 2)$

Next, determine the acceleration a by differentiating the velocity function with respect to time t:

$a = \frac{dv}{dt} = \frac{d}{dt}[2c_0t + 2c(t - 2)]$

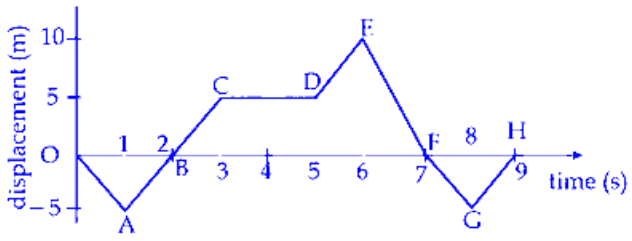
Calculating this gives:

$a = 2c_0 + 2c$

Hence, the acceleration of the particle is $2c_0 + 2c$.

Question28

The displacement x versus time graph is shown below.



(A) The average velocity during 0 to 3 s is $10\ \mathrm{m/s}$

(B) The average velocity during 3 to 5 s is $0\ \mathrm{m/s}$

(C) The instantaneous velocity at $\mathrm{t} = 2\ \mathrm{s}$ is $5\ \mathrm{m/s}$

(D) The average velocity during 5 to 7 s and instantaneous velocity at $\mathrm{t} = 6.5\ \mathrm{s}$ are equal

(E) The average velocity from $t = 0$ to $t = 9\ \mathrm{s}$ is zero

Choose the correct answer from the options given below :

JEE Main 2025 (Online) 4th April Evening Shift

Options:

A. (B), (C), (D) only

B. (B), (D), (E) only

C. (A), (D), (E) only

D. (B), (C), (E) only

Answer: D

Solution:

Average Velocity $\langle \vec{v} \rangle$: Calculated using the formula

$\langle \vec{v} \rangle = \frac{\Delta \vec{s}}{\Delta t} = \frac{S_f - S_i}{t_f - t_i}$

where S_f and S_i are the final and initial displacements, respectively, and t_f and t_i are the final and initial times.

Instantaneous Velocity $\vec{v}$: Given by the slope of the displacement vs. time graph at any specific time:

$\vec{v} = \frac{ds}{dt}$ = slope at that point

Analysis of Each Time Interval:

(A) From 0 **to** 3 sec**:**

$\langle \vec{v} \rangle = \frac{5-0}{3} = \frac{5}{3}$ m/s

The statement that the average velocity is 10 m/s is incorrect based on our calculation.

(B) From 3 **to** 5 sec**:**

$\langle \vec{v} \rangle = \frac{5-5}{2} = 0$ m/s

The average velocity is indeed 0 m/s.

(C) At $t = 2$ sec**:**

The slope of the tangent line at $t = 2$ indicates that $\vec{v} = 5$ m/s. Therefore, this statement is correct.

(D) From 5 **to** 7 sec**:**

$\langle \vec{v} \rangle = \frac{0-5}{2} = -2.5\,\text{m/s}$

At $t = 6.5$ sec, the graph's slope shows that $\vec{v} = 10\,\text{m/s}$, hence the statement is incorrect as the values are not equal.

(E) From $t = 0$ to $t = 9$ sec:

$\langle \vec{v} \rangle = \frac{0-0}{9} = 0\,\text{m/s}$

This statement is verified correct as the average velocity is zero over the entire period.

Based on the analysis, statements (B), (C), and (E) are correct.

Question29

A particle starts from origin at $t = 0$ with a velocity $5\hat{i}\,\text{m/s}$ and moves in $x-y$ plane under action of a force which produces a constant acceleration of $(3\hat{i} + 2\hat{j})\,\text{m/s}^2$. If the x-coordinate of the particle at that instant is 84m, then the speed of the particle at this time is $\sqrt{\alpha}\,\text{m/s}$. The value of α is____ *[27-Jan-2024 Shift 1]*

Answer: 673

Solution:

$u_x = 5\text{m/s}\quad a_x = 3\text{m/s}^2\quad x = 84\text{m}$

$v_x^2 - u_x^2 = 2ax$

$v_x^2 - 25 = 2(3)(84)$

$V_x = 23\text{m/s}$

$v_x - u_x = a_x t$

$t = \frac{23-5}{3} = 6\,s$

$v_y = 0 + a_y t = 0 + 2 \times (6) = 12\text{m/s}$

$v^2 = v_x^2 + v_y^2 = 23^2 + 12^2 = 673$

$v = \sqrt{673}\,\text{m/s}$

Question30

A bullet is fired into a fixed target looses one third of its velocity after travelling 4cm. It penetrates further D × 10^{-3}m before coming to rest. The value of D is :

[27-Jan-2024 Shift 2]

Options:

A.

2

B.

5

C.

3

D.

None of above

Answer: D

Solution:

$$v^2 - u^2 = 2aS$$

$$\left(\frac{2u}{3}\right)^2 = u^2 + 2(-a)(4 \times 10^{-2})$$

$$\frac{4u^2}{9} = u^2 - 2a(4 \times 10^{-2})$$

$$-\frac{5u^2}{9} = -2a(4 \times 10^{-2}) \ldots (1)$$

$$0 = \left(\frac{2u}{3}\right)^2 + 2(-a)(x)$$

$$-\frac{4u^2}{9} = -2ax \ldots (2)$$

(1) /(2)

$$\frac{5}{4} = \frac{4 \times 10^{-2}}{x}$$

$$x = \frac{16}{5} \times 10^{-2}$$

$$x = 3 \cdot 2 \times 10^{-2}\text{m}$$

$$x = 32 \times 10^{-3}\text{m}$$

Note : Since no option is matching, Question should be bonus.

Question31

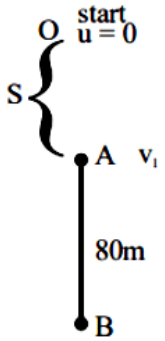
A body falling under gravity covers two points A and B separated by 80m in 2 s. The distance of upper point A from the starting point is____ m (. use g = 10ms^{-2})

[27-Jan-2024 Shift 2]

Options:

Answer: 45

Solution:



From $A \longrightarrow B$

$$-80 = -v_1 t - \frac{1}{2} \times 10t^2$$

$$-80 = -2v_1 - \frac{1}{2} \times 10 \times 2^2$$

$$-80 = -2v_1 - 20$$

$$-60 = -2v_1$$

$$v_1 = 30 m/s$$

From O to A

$$v^2 = u^2 + 2gS$$

$$30^2 = 0 + 2 \times (-10)(-S)$$

$$900 = 20S$$

$$S = 45m$$

Question32

A body starts moving from rest with constant acceleration covers displacement S1 in first (p − 1) seconds and S2 in first p seconds. The displacement $S_1 + S_2$ will be made in time :

[29-Jan-2024 Shift 1]

Options:

A.

(2p + 1) s

B.

$\sqrt{(2p^2 - 2p + 1)s}$

C.

(2p − 1) s

D.

$(2p^2 - 2p + 1)$s

Answer: B

Solution:

S_1 in first $(p-1)$ *sec*

S_2 in first p sec

$$S_1 = \frac{1}{2}a(p-1)^2$$

$$S_2 = \frac{1}{2}a(p)^2$$

$$S_1 + S_2 = \frac{1}{2}at^2$$

$$(p-1)^2 + p^2 = t^2$$

$$t = \sqrt{2p^2 + 1 - 2p}$$

Question33

A particle is moving in a straight line. The variation of position ' x ' as a function of time ' t ' is given as

$x = (t^3 - 6t^2 + 20t + 15)$m. The velocity of the body when its acceleration becomes zero is :

[29-Jan-2024 Shift 2]

Options:

A.

4m/s

B.

8m/s

C.

10m/s

D.

6m/s

Answer: B

Solution:

$x = t^3 - 6t^2 + 20t + 15$

$\frac{dx}{dt} = v = 3t^2 - 12t + 20$

$\frac{dv}{dt} = a = 6t - 12$

When $a = 0$

$6t - 12 = 0; t = 2\ sec$

At $t = 2\ sec$

$v = 3(2)^2 - 12(2) + 20$

$v = 8m/s$

Question34

A particle is moving in a circle of radius 50cm in such a way that at any instant the normal and tangential components of its acceleration are equal. If its speed at t = 0 is 4m/s, the time taken to complete the first revolution will be $\frac{1}{\alpha}[1 - e^{-2\pi}]\ s$, where α =

[29-Jan-2024 Shift 2]

Answer: 8

Solution:

$$|\vec{a}_c| = |\vec{a}_t|$$

$$\frac{v^2}{r} = \frac{dv}{dt}$$

$$\Rightarrow \int_4^v \frac{dv}{v^2} = \int_0^t \frac{dt}{r}$$

$$\Rightarrow \left[\frac{-1}{v}\right]_4^v = \frac{t}{r}$$

$$\Rightarrow \frac{-1}{v} + \frac{1}{4} = 2t$$

$$\Rightarrow v = \frac{4}{1-8t} = \frac{ds}{dt}$$

$$4\int_0^t \frac{dt}{1-8t} = \int_0^s ds$$

$(r = 0.5m$

$s = 2\pi r = \pi)$

$$4\times \frac{[\ln(1-8t)]_0^t}{-8} = \pi$$

$$\ln(1-8t) = -2\pi$$

$$1-8t = e^{-2\pi}$$

$$t = (1-e^{-2\pi})\frac{1}{8}s$$

So, $\alpha = 8$

Question35

The displacement and the increase in the velocity of a moving particle in the time interval of t to (t + 1) s are 125m and 50m/s, respectively. The distance travelled by the particle in $(t + 2)^{th}$ s is ____m.

[30-Jan-2024 Shift 1]

Answer: 175

Solution:

Considering acceleration is constant

$v = u + at$

$u + 50 = u + a \Rightarrow a = 50\text{m}/s^2$

$125 = ut + \frac{1}{2}at^2$

$125 = u + \frac{a}{2}$

$\Rightarrow u = 100\text{m}/s$

$\therefore S_{n^{th}} = u + \frac{a}{2}[2n-1]$

$= 175\text{m}$

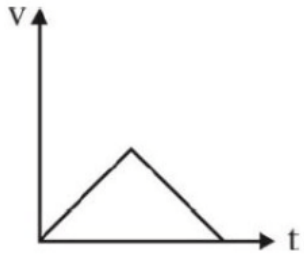
Question36

A small steel ball is dropped into a long cylinder containing glycerine. Which one of the following is the correct representation of the velocity time graph for the transit of the ball?

[31-Jan-2024 Shift 1]

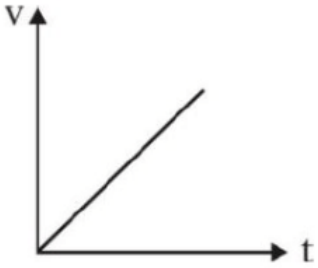
Options:

A.

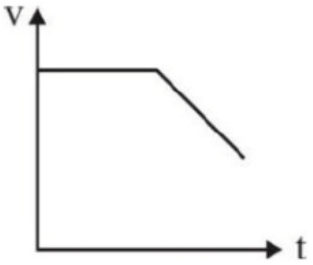


B.

C.

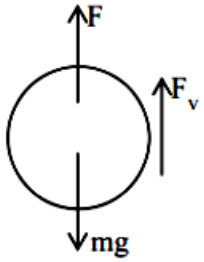


D.



Answer: B

Solution:



$$mg - F_B - F_v = ma$$

$$\left(\rho \frac{4}{3}\pi r^3\right)g - \left(\rho_L \frac{4}{3}\pi r^3\right)g - 6\pi\eta rv = m\frac{dv}{dt}$$

Let $\frac{4}{3m}\pi R^3 g(\rho - \rho_L) = K_1$ and $\frac{6\pi\eta r}{m} = K_2$

$$\frac{dv}{dt} = K_1 - K_2 v$$

$$\int_0^v \frac{dv}{K_1 - K_2 v} = \int_0 t\,dt$$

$$-\frac{1}{K_2}\ln[K_1 - K_2 v]_0^v = t$$

$$\ell n\left(\frac{K_1 - K_2 v}{K_1}\right) = -K_2 t$$

$$K_1 - K_2 v = K_1 e^{-K_2 t}$$

$$v = \frac{K_1}{K_2}[1 - e^{-K_2 t}]$$

Question37

The relation between time ' t ' and distance ' x ' is $t = \alpha x^2 + \beta x$, where α and β are constants. The relation between acceleration (a) and velocity (v) is:

[31-Jan-2024 Shift 1]

Options:

A.

$a = -2\alpha v^3$

B.

$a = -5\alpha v^5$

C.

$a = -3\alpha v^2$

D.

$a = -4\alpha v^4$

Answer: A

Solution:

$t = \alpha x^2 + \beta x$ (differentiating wrt time)

$$\frac{dt}{dx} = 2\alpha x + \beta$$

$$\frac{1}{v} = 2\alpha x + \beta$$

(differentiating wrt time)

$$-\frac{1}{v^2}\frac{dv}{dt} = 2\alpha \frac{dx}{dt}$$

$$\frac{dv}{dt} = -2\alpha v^3$$

Question38

If the radius of curvature of the path of two particles of same mass are in the ratio 3:4, then in order to have constant centripetal force, their velocities will be in the ratio of:

[29-Jan-2024 Shift 1]

Options:

A.

√3 : 2

B.

1 : √3

C.

√3 : 1

D.

2 : √3

Answer: A

Solution:

Given $m_1 = m_2$ and $\frac{r_1}{r_2} = \frac{3}{4}$

As centripetal force $F = \frac{m^2}{r}$

In order to have constant (same in this question) centripetal force

$F_1 = F_2$

$$\frac{m_1 v_1^2}{r_1} = \frac{m_2 v_2^2}{r_2}$$

$$\Rightarrow \frac{v_1}{v_2} = \sqrt{\frac{r_1}{r_2}} = \frac{\sqrt{3}}{2}$$

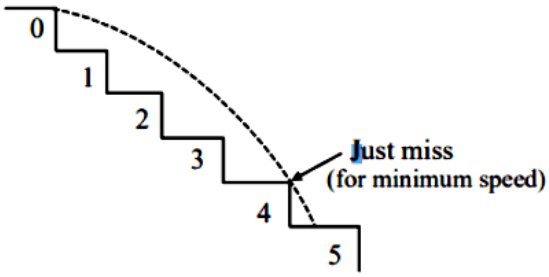
Question39

A ball rolls off the top of a stairway with horizontal velocity u. The steps are 0.1m high and 0.1m wide. The minimum velocity u with which that ball just hits the step 5 of the stairway will be $\sqrt{x}ms^{-1}$ where x = _____ [use g = 10m/s^2].

[29-Jan-2024 Shift 1]

Answer: 2

Solution:



The ball needs to just cross 4 steps to just hit 5^{th} step

Therefore, horizontal range $(R) = 0.4m$

$R = u.t$

Similarly, in vertical direction

$h = \frac{1}{2}gt^2$

$0.4 = \frac{1}{2}gt^2$

$0.4 = \frac{1}{2}g\left(\frac{0.4}{u}\right)^2$

$u^2 = 2$

$u = \sqrt{2}m/s$

Therefore, $x = 2$

Question40

A particle of mass m projected with a velocity ' u ' making an angle of 30◦ with the horizontal. The magnitude of angular momentum of the projectile about the point of projection when the particle is at its maximum height h is :

[30-Jan-2024 Shift 1]

Options:

A.

$$\frac{\sqrt{3}}{16}\frac{mu^3}{g}$$

B.

$$\frac{\sqrt{3}}{2}\frac{mu^2}{g}$$

C.

$$\frac{mu^3}{\sqrt{2}g}$$

D.

zero

Answer: A

Solution:

$$\mathrm{L} = mu\cos\theta H$$

$$= mu\cos\theta \times \frac{u^2 sin^2\theta}{2g}$$

$$= \frac{mu^3}{2g} \times \frac{\sqrt{3}}{2} \times \left(\frac{1}{2}\right)^2 = \frac{\sqrt{3}mu^3}{16g}$$

Question41

Projectiles A and B are thrown at angles of 45◦ and 60◦ with vertical respectively from top of a 400m high tower. If their ranges and times of flight are same, the ratio of their speeds of projection $v_A : v_B$ is :

[30-Jan-2024 Shift 2]

Options:

A.

1 : √3

B.

√2 : 1

C.

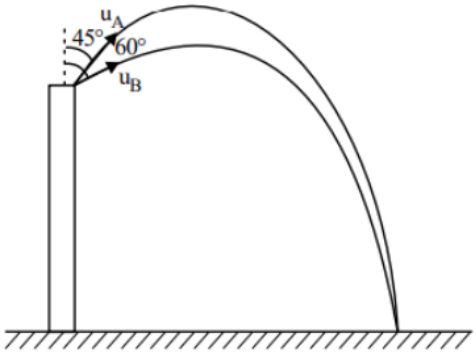
1:2

D.

None of above

Answer: D

Solution:



For u_A & u_B time of flight and range can not be same. So above options are incorrect.

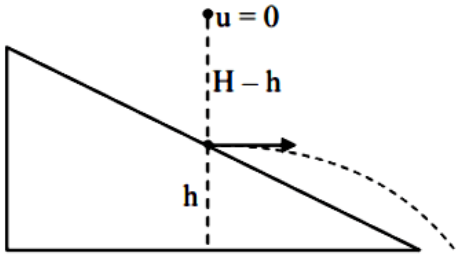
Question42

A body starts falling freely from height H hits an inclined plane in its path at height h. As a result of this perfectly elastic impact, the direction of the velocity of the body becomes horizontal. The value of H/h for which the body will take the maximum time to reach the ground is_____

[31-Jan-2024 Shift 1]

Answer: 2

Solution:



Total time of flight $= T$

$$T = \sqrt{\frac{2h}{g}} + \sqrt{\frac{2(H-h)}{g}}$$

For max. time $= \frac{dT}{dh} = 0$

$$\sqrt{\frac{2}{g}}\left(\frac{-1}{2\sqrt{H-h}} + \frac{1}{2\sqrt{h}}\right) = 0$$

$$\sqrt{H-h} = \sqrt{h}$$

$$h = \frac{H}{2} \Rightarrow \frac{H}{h} = 2$$

Question43

A particle is moving in one dimension (along x axis) under the action of a variable force. It's initial position was 16m right of origin. The variation of its position (x) with time (t) is given as $x = -3t^3 + 18t^2 + 16t$, where x is in m and t is in s. The velocity of the particle when its acceleration becomes zero is_____ m/s.

[1-Feb-2024 Shift 1]

Answer: 52

Solution:

$x = 3t^3 + 18t^2 + 16t$

$v = -9t^2 + 36 + 16$

$a = -18t + 36$

$a = 0 \text{ at t } = 2s$

$v = -9(2)^2 + 36 \times 2 + 16$

$v = 52\text{m} / s$

Question44

Train A is moving along two parallel rail tracks towards north with speed 72km/h and train B is moving towards south with speed 108km/h. Velocity of train B with respect to A and velocity of ground with respect to B are (in ms^{-1}) :

[1-Feb-2024 Shift 2]

Options:

A.

-30 and 50

B.

-50 and -30

C.

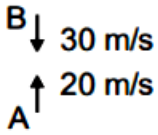
-50 and 30

D.

50 and -30

Answer: C

Solution:



$< V_A = 20 m/s$

$V_B = -30 m/s$

Velocity of B w.r.t. A

$V_{B/A} = -50 m/s$

Velocity of ground w.r.t. B

$V_{G/B} = 30 m/s$br>

Question45

A particle initially at rest starts moving from reference point. x = 0 along x-axis, with velocity v that varies as v = 4√xm/s. The acceleration of the particle is____ ms^{-2}.

[1-Feb-2024 Shift 2]

Answer: 8

Solution:

$V = 4\sqrt{x}$

$a = V\frac{dv}{dx}$

$= 4\sqrt{x} \times 4 \times \frac{1}{2}x^{-1/2} = 8 m/s^2$

Question46

A particle moving in a circle of radius R with uniform speed takes time T to complete one revolution. If this particle is projected with the same speed at an angle θ to the horizontal, the maximum height attained by it is equal to 4R. The angle of projection θ is then given by :

[1-Feb-2024 Shift 1]

Options:

A.

$$sin^{-1}\left[\frac{2gT^2}{\pi^2 R}\right]^{\frac{1}{2}}$$

B.

$$sin^{-1}\left[\frac{\pi^2 R}{2gT^2}\right]^{\frac{1}{2}}$$

C.

$$\cos^{-1}\left[\frac{2gT^2}{\pi^2 R}\right]^{\frac{1}{2}}$$

D.

$$\cos^{-1}\left[\frac{\pi R}{2gT^2}\right]^{\frac{1}{2}}$$

Answer: A

Solution:

$$\frac{2\pi R}{T} = V$$

$$\text{Maximum height } H = \frac{v^2 sin^2\theta}{2g}$$

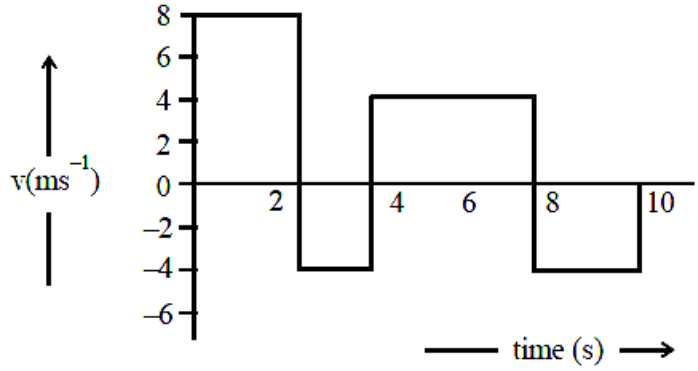
$$4R = \frac{4\pi^2 R^2}{T^2 2g} sin^2\theta$$

$$sin\,\theta = \sqrt{\frac{2gT^2}{\pi^2 R}}$$

$$\theta = sin^{-1}\left(\frac{2gT^2}{\pi^2 R}\right)^{\frac{1}{2}}$$

Question47

The velocity time graph of a body moving in a straight line is shown in figure.



The ratio of displacement to distance travelled by the body in time 0 to 10 s is
[24-Jan-2023 Shift 2]

Options:

A. 1 : 1

B. 1 : 4

C. 1 : 2

D. 1 : 3

Answer: D

Solution:

Solution:
Displacement = area $= 16 - 8 + 16 - 8 = 16\text{m}$
Distance $= \Sigma|\text{ area }| = 48\text{m}$
$\frac{\text{displacement}}{\text{Distance}} = \frac{1}{3}$

Question48

A car travels a distance of ' x ' with speed V_1 and then same distance ' x ' with speed V_2 in the same direction. The average speed of the car is:
[25-Jan-2023 Shift 1]

Options:

A. $\frac{v_1 v_2}{2(v_1 + v_2)}$

B. $\frac{v_1 + v_2}{2}$

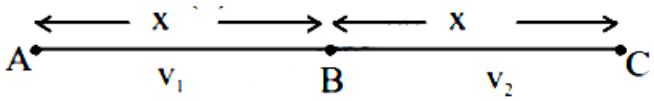
C. $\frac{2x}{v_1 + v_2}$

D. $\frac{2v_1 v_2}{v_1 + v_2}$

Answer: D

Solution:

Solution:



$$\text{Average velocity} = \frac{\text{Total displacement}}{\text{Total time}}$$

$$= \frac{x+x}{\frac{x}{v_1}+\frac{x}{v_2}} = \frac{2v_1v_2}{v_1+v_2}$$

Question49

The distance travelled by a particle is related to time t as $x = 4t^2$. The velocity of the particle at t = 5 s is.
[25-Jan-2023 Shift 2]

Options:

A. $40ms^{-1}$

B. $25ms^{-1}$

C. $20ms^{-1}$

D. $8ms^{-1}$

Answer: A

Solution:

Solution:

$x = 4t^2$

$v = \frac{dx}{dt} = 8t$

At t = 5 sec

$v = 8 \times 5 = 40m/s$

Question50

A tennis ball is dropped on to the floor from a height of 9.8m. It rebounds to a height 5.0m. Ball comes in contact with the floor for 0.2 s. The average acceleration during contact is _____ ms^{-2}.
[Given $g = 10ms^{-2}$]
[29-Jan-2023 Shift 1]

Answer: 120

Solution:

Solution:

$v_i = \sqrt{2gh_i}$

$= \sqrt{2 \times 10 \times 9.8}\downarrow$

$= 14\text{m/ s}\downarrow$

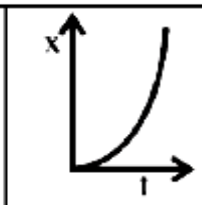
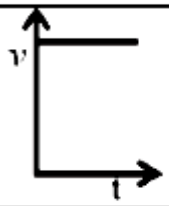
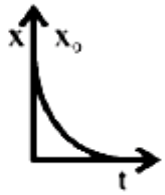
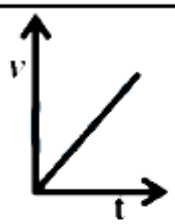
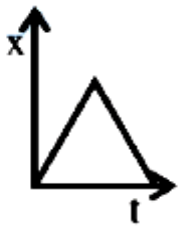
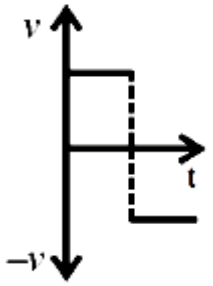
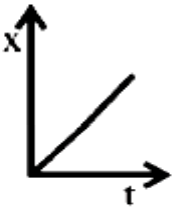
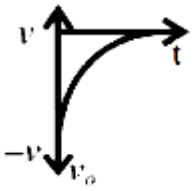
$v_f = \sqrt{2gh_f}$

$= \sqrt{2 \times 10 \times 5}\uparrow$

$= 10\text{m/ s}\uparrow$

$\left|\vec{a}_{avg}\right| = \left|\Delta\frac{\vec{v}}{\Delta t}\right| = \frac{24}{0.2} = 120\text{m/ s}^2$

Question51

Column-I (x-t graphs)		Column-II (v-t graphs)	
A.		I.	
B.		II.	
C.		III.	
D.		IV.	

Choose the correct answer from the options given below:
[30-Jan-2023 Shift 1]

Options:

A. A-II B-IV, C-III, D-I

B. A- I. B-II, C-III, D-IV

C. A- II B-III, C-IV, D-I

D. A- I, B-III. C-IV, D-II

Answer: A

Solution:

Solution:
$\frac{dx}{dt}$ = slope ≥ 0 always increasing
(A - II)
$\frac{dx}{dt} < 0$; and at $t \to \infty$ $\frac{dx}{dt} \to 0$
(B - IV)
$\frac{dx}{dt} > 0$ for first half $\frac{dx}{dt} < 0$ for second half.
(C - III)
$\frac{dx}{dt}$ = constant
(D - I)

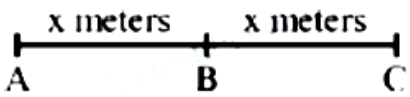
Question52

A horse rider covers half the distance with 5m/ s speed. The remaining part of the distance was travelled with speed 10m/ s for half the time and with speed 15m/ s for other half of the time. The mean speed of the rider averaged over the whole time of motion is x/7m/ s. The value of x is
[30-Jan-2023 Shift 1]

Answer: 50

Solution:

Solution:



$t_{AB} = \frac{x}{5m/s}$
In motion BC
$x = d_1 + d_2$

where $d_1 \& d_2$ we the distance travelled with 10 m/s and $15 m/s$ respectively in equal time intervals $\frac{'t'}{2}$ each

$d_1 = \frac{10t}{2}, d_2 = \frac{15t}{2}$

$d_1 + d_2 = x = \frac{t}{2}(10 + 15) = \frac{25t}{2}$

$< v > = \frac{2x}{\frac{x}{5} + \frac{2x}{25}} = \frac{2 \times 25}{5 + 2} = \frac{50}{7} m/s$

Ans. : 50

Question53

An object is allowed to fall from a height R above the earth, where R is the radius of earth. Its velocity when it strikes the earth's surface, ignoring air resistance, will be : [30-Jan-2023 Shift 2]

Options:

A. $2\sqrt{gR}$

B. $\sqrt{gR}$

C. $\sqrt{\frac{gR}{2}}$

D. $\sqrt{2gR}$

Answer: B

Solution:

Solution:

Loss in PE = Gain in KE

$\left(-\frac{GMm}{2R}\right) - \left(-\frac{GMm}{R}\right) = \frac{1}{2} mv^2$

$\Rightarrow v^2 = \frac{GM}{R} = gR$

$\Rightarrow v = \sqrt{gR}$

Question54

A vehicle travels 4 km with speed of 3 km/h and another 4 km with speed of 5 km/h, then its average speed is: [30-Jan-2023 Shift 2]

Options:

A. 4.25 km/h

B. 3.50 km/h

C. 4.00 km/h

D. 3.75 km/h

Answer: D

Solution:

Solution:

$$\frac{2}{V_{av}} = \frac{1}{3} + \frac{1}{5} = \frac{8}{15}$$

$$\Rightarrow \quad V_{av} = \frac{15}{4} = 3.75\,\text{km/h}$$

Question55

A body is moving with constant speed, in a circle of radius 10m. The body completes one revolution in 4 s. At the end of 3 rd second, the displacement of body (in m) from its starting point is:
[31-Jan-2023 Shift 2]

Options:

A. 30

B. 15π

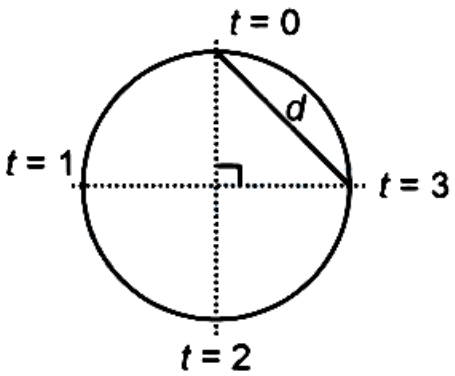
C. 5π

D. $10\sqrt{2}$

Answer: D

Solution:

Solution:



$$\omega = \frac{2\pi}{T} = \frac{2\pi}{4} = \frac{\pi}{2}\,\text{rad/s}$$

$$\theta = \omega t$$

$$\theta = \frac{\pi}{2} \times 3$$

$$\theta = \frac{3\pi}{2}\,\text{rad}$$

r = 10m
T = 4 sec
d = $\sqrt{2}$(10)m

Question56

The maximum vertical height to which a man can throw a ball is 136m. The maximum horizontal distance upto which he can throw the same ball is
[24-Jan-2023 Shift 1]

Options:

A. 192m

B. 272m

C. 136m

D. 68m

Answer: B

Solution:

Solution:

$H_{max} = \frac{v^2}{2g} = 136m$

$R_{max} = \frac{v^2}{g} = 2H_{max}$

$= 2(136)$

$= 272m$

Question57

Two objects are projected with same velocity 'u' however at different angles α and β with the horizontal. If α + β = 90°, the ratio of horizontal range of the first object to the 2 nd object will be :
[25-Jan-2023 Shift 2]

Options:

A. 4 : 1

B. 2 : 1

C. 1 : 2

D. 1 : 1

Answer: D

Solution:

Solution:

$$\text{Range} = \frac{u^2 \sin 2\theta}{g}$$

Range for projection angle " α "

$$R_1 = \frac{u^2 \sin 2\alpha}{g}$$

Range for projection angle " β "

$$R_2 = \frac{u^2 \sin 2\beta}{g}$$

$$\alpha + \beta = 90^\circ \text{ (Given)}$$

$$\Rightarrow \beta = 90^\circ - \alpha$$

$$R_2 = \frac{u^2 \sin 2(90^\circ - \alpha)}{g}$$

$$R_2 = \frac{u^2 \sin (180^\circ - 2\alpha)}{g}$$

$$R_2 = \frac{u^2 \sin 2\alpha}{g}$$

$$\Rightarrow \frac{R_1}{R_2} = \frac{\left(\frac{u^2 \sin 2\alpha}{g}\right)}{\left(\frac{u^2 \sin 2\alpha}{g}\right)} = \frac{1}{1}$$

Question58

A stone is projected at angle 30° to the horizontal. The ratio of kinetic energy of the stone at point of projection to its kinetic energy at the highest point of flight will be : [29-Jan-2023 Shift 1]

Options:

A. 1 : 2

B. 1 : 4

C. 4 : 1

D. 4 : 3

Answer: D

Solution:

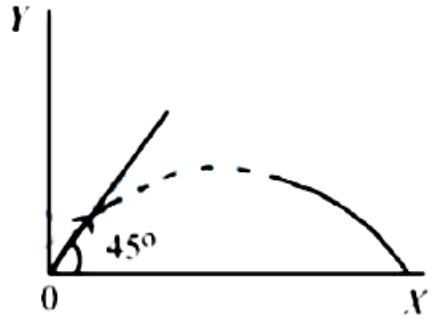
Solution:

$$\frac{KE_{POP}}{KE_{top}} = \frac{\frac{1}{2}M(u)^2}{\frac{1}{2}M(u\cos 30^\circ)^2} = \frac{4}{3}$$

Question59

A particle of mass 100g is projected at time t = 0 with a speed 20ms^{-1} at an angle 45° to the horizontal as given in the figure. The magnitude of the angular momentum of the particle about the starting point at time t = 2s is found to be $\sqrt{K}$ kg m^2/ s. The value of

K is _____.
(. Take g = 10ms^{-2})



[29-Jan-2023 Shift 2]

Answer: 800

Solution:

Solution:

Use $\Delta L = \int_0^t \tau\, dt$

$L_0 = \int_{0^2}^{x} mg(v\, t)\, dt$

$= mgv_x \frac{t^2}{2} = (0.1)(10)(10\sqrt{2})\frac{2^2}{2}$

$= 20\sqrt{2}$

$= \sqrt{800}\, kgm^2/s$

Question60

The initial speed of a projectile fired from ground is u. At the highest point during its motion, the speed of projectile is $\frac{\sqrt{3}}{2}$u. The time of flight of the projectile is:
[31-Jan-2023 Shift 1]

Options:

A. $\frac{u}{2g}$

B. $\frac{u}{g}$

C. $\frac{2u}{g}$

D. $\frac{\sqrt{3}u}{g}$

Answer: B

Solution:

Solution:

$u\cos\theta = \frac{\sqrt{3}u}{2} \Rightarrow \cos\theta = \frac{\sqrt{3}}{2}$

$\Rightarrow \theta = 30^{\circ}$

$T = \frac{2u\sin 30^{\circ}}{g} = \frac{u}{g}$

Option 2.

Question61

The speed of a swimmer is 4 km h^{-1} in still water. If the swimmer makes his strokes normal to the flow of river of width 1 km, he reaches a point 750m down the stream on the opposite bank.

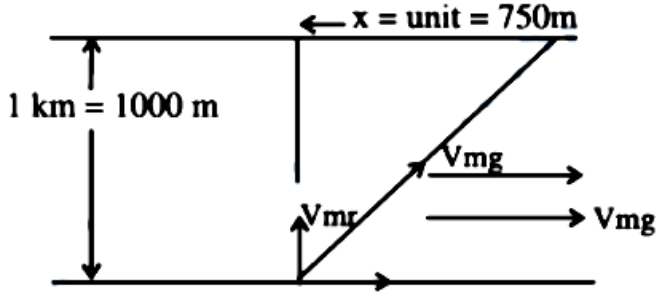
The speed of the river water is _____ km h^{-1}.

[31-Jan-2023 Shift 1]

Answer: 3

Solution:

Solution:



time to cross the River width $\omega = 1000\text{m}$

$\text{is} = \frac{1\,\text{km}}{4\,\text{km/h}}$

Drift $x = Vm/g \times t$

Where Vm/g is velocity of River w.r. to ground.

$x = Vm/g \times \frac{1}{4} = 750\text{m} = \frac{3}{4}\,\text{km}$

$Vm/g = 3\,\text{km/hr}$

Ans is $3\,\text{km/hr}$.

Question62

Two bodies are projected from ground with same speeds 40 ms^{-1} at two different angles with respect to horizontal. The bodies were found to have same range. If one of the body was projected at an angle of 60°, with horizontal then sum of the maximum

heights, attained by the two projectiles, is _____ m. (Given g = 10ms^{-2})
[31-Jan-2023 Shift 2]

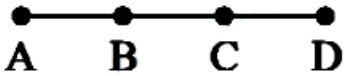
Answer: 80

Solution:

Solution:
Since range is same.
$\Rightarrow \theta_1 + \theta_2 = 90^\circ$
$\Rightarrow \theta_2 = 30^\circ$
$\Rightarrow (H_{max})_1 + (H_{max})_2 = \frac{u^2 \sin^2 \theta_1}{2g} + \frac{u^2 \sin^2 \theta_2}{2g}$
$= \frac{40^2}{20}\left(\frac{1}{4} + \frac{3}{4}\right) = 80\text{m}$

Question63

An object moves with speed v_1, v_2, and v_3 along a line segment AB, BC and CD respectively as shown in figure. Where AB = BC and AD = 3 AB, then average speed of the object will be :



[1-Feb-2023 Shift 1]

Options:

A. $\frac{(v_1 + v_2 + v_3)}{3}$

B. $\frac{v_1 v_2 v_3}{3(v_1 v_2 + v_2 v_3 + v_3 v_1)}$

C. $\frac{3v_1 v_2 v_3}{v_1 v_2 + v_2 v_3 + v_3 v_1}$

D. $\frac{(v_1 + v_2 + v_3)}{3v_1 v_2 v_3}$

Answer: C

Solution:

Solution:
AB = x
BC = x
2x + CD = 3x
CD = x
$\langle v \rangle = \frac{3x}{\frac{x}{v_1} + \frac{x}{v_2} + \frac{x}{v_3}} = \frac{3v_1 v_2 v_3}{v_2 v_3 + v_1 v_3 + v_1 v_2}$

Question64

For a train engine moving with speed of $20ms^{-1}$. the driver must apply brakes at a distance of 500m before the station for the train to come to rest at the station. If the brakes were applied at half of this distance, the train engine would cross the station with speed $\sqrt{x}ms^{-1}$. The value of x is _____
(Assuming same retardation is produced by brakes)
[1-Feb-2023 Shift 2]

Answer: 200

Solution:

Solution:
$u = 20m/s$, $S_1 = 500m$, $v = 0$
By third equation of mation
$0 = (20)^2 - 2a.500 \Rightarrow a = \frac{4}{10}m/s^2$
$u = 20m/s$, $S_2 = 250m$, $v = ?$
$v^2 = (20)^2 - 2a.250$
$= v = \sqrt{200}m/s$
$x = 200$

Question65

A child stands on the edge of the cliff 10m above the ground and throws a stone horizontally with an initial speed of $5ms^{-1}$. Neglecting the air resistance, the speed with which the stone hits the ground will be _____ ms^{-1} (given, $g = 10ms^{-2}$).
[1-Feb-2023 Shift 1]

Options:

A. 20

B. 15

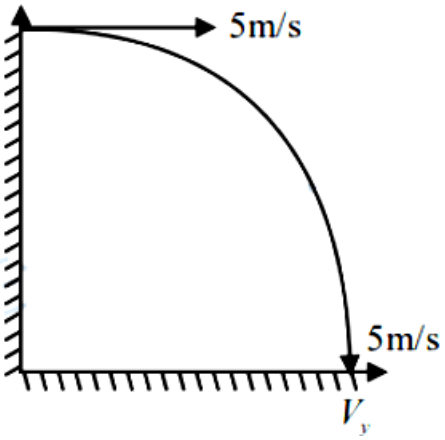
C. 30

D. 25

Answer: B

Solution:

Solution:



$v_y = \sqrt{2gh} = \sqrt{200}$

$v_{net} = \sqrt{25+200} = 15 m/s$

Question66

A particle of mass 10g moves in a straight line with retardation 2x, where x is the displacement in SI units. Its loss of kinetic energy for above displacement is $\left(\frac{10}{x}\right)^{-n}$ J. The value of n will be _____
[6-Apr-2023 shift 1]

Answer: 2

Solution:

Solution:

Given, $a = -2x$

$\Rightarrow \frac{v\,dv}{dx} = -2x$

$\Rightarrow v\,dv = -2x\,dx$

$\Rightarrow \int_{v_1} v_2 v\,dv = -2\int_0^x x\,dx$

$\Rightarrow \frac{v_2^2}{2} - \frac{v_1^2}{2} = -\frac{2x^2}{2}$

$\Rightarrow \frac{mv_1^2}{2} - \frac{mv_2^2}{2} = mx^2 = \frac{10}{1000}x^2 = 10^{-2}x^2 = \left(\frac{10}{x}\right)^{-2}$

$n = 2.$

Question67

A particle starts with an initial velocity of $10.0 ms^{-1}$ along x-direction and accelerates uniformly at the rate of $2.0 ms^{-2}$. The time taken by the particle to reach the velocity of $60.0 ms^{-1}$ is
[6-Apr-2023 shift 2]

Options:

A. 3 s

B. 6 s

C. 25 s

D. 30 s

Answer: C

Solution:

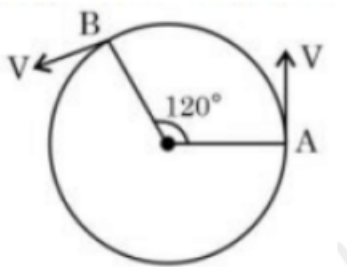
Solution:
Using I st equation of motion

$t = \frac{v - u}{a}$

$t = \frac{60 - 10}{2} = \frac{50}{2} = 25 \text{ sec}$

Question68

As shown in the figure, a particle is moving with constant speed πm/ s. Considering its motion from A to B, the magnitude of the average velocity is :



[6-Apr-2023 shift 2]

Options:

A. πm/ s

B. $2\sqrt{3}$m/ s

C. $\sqrt{3}$m/ s

D. $1.5\sqrt{3}$m/ s

Answer: D

Solution:

Solution:
Given speed v = πm/ s
or Rω = π
or $\omega = \frac{\pi}{R}$ rad/ s
angular displacement θ = 120° or $\frac{2\pi}{3}$
uising θ = ωt

$t = \frac{\theta}{\omega} = \frac{2\pi/3}{\pi/R} = \frac{2R}{3}$

linear displacement $d = 2R\sin(\theta/2)$

$d = 2R\sin\left(\frac{120}{2}\right)$

$= 2R \times \sin 60 = 2R \times \frac{\sqrt{3}}{2}$

$= R\sqrt{3}$

average velocity $= \frac{d}{t} = \frac{R\sqrt{3}}{2R/3} = \frac{3\sqrt{3}}{2}$

Question69

A particle is moving with constant speed in a circular path. When the particle turns by an angle 90°, the ratio of instantaneous velocity to its average velocity is $\pi : x\sqrt{2}$. The value of x will be -
[6-Apr-2023 shift 1]

Options:

A. 7

B. 2

C. 1

D. 5

Answer: B

Solution:

Solution:

$V_A = v\hat{j}$

And $V_B = -v\hat{i}$

Time to reach from A to B $= \frac{2\pi R}{4} \times \frac{1}{v} = \frac{\pi R}{2v}$

Displacement from A to B $= R\sqrt{2}$

Now, Average velocity from A to B $= \frac{\text{Displacement}}{\text{Time}} = \frac{R\sqrt{2}}{\frac{\pi R}{2v}} = \frac{2\sqrt{2}v}{\pi}$

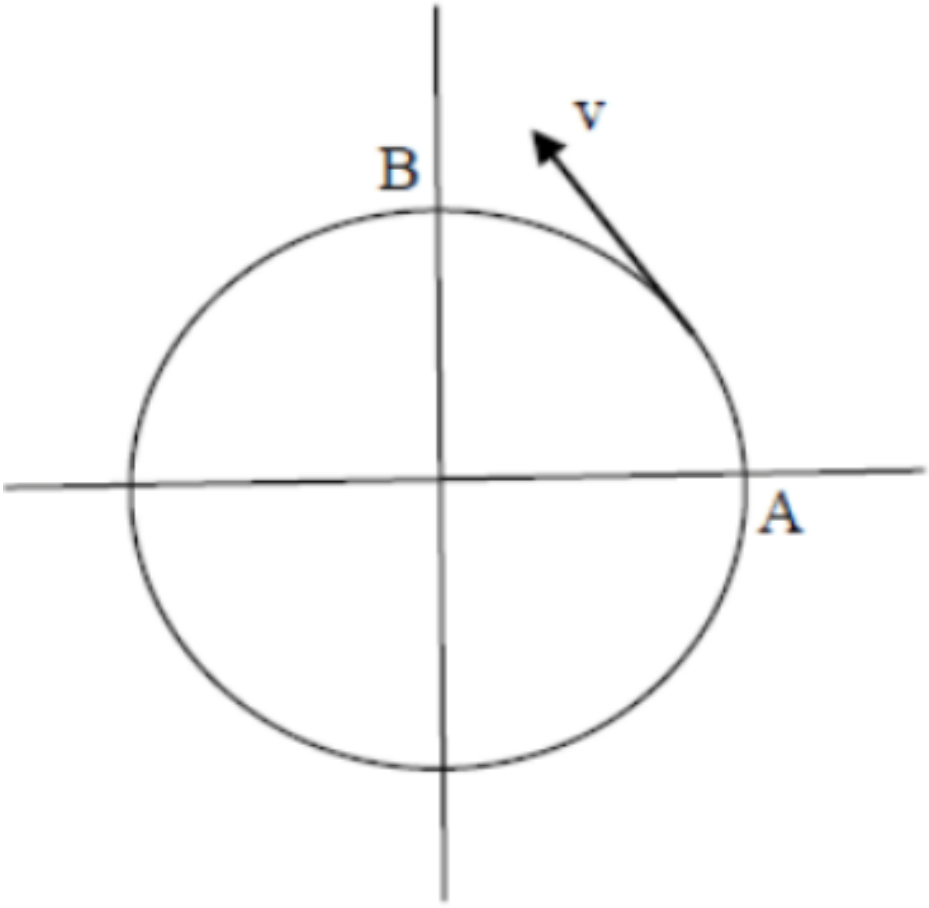
Instantaneous velocity at B is $-v\hat{i}$

According to question, $\frac{\text{instantaneous velocity}}{\text{average velocity}} = \frac{\pi}{x\sqrt{2}}$

$\frac{v}{\frac{2\sqrt{2}v}{\pi}} = \frac{\pi}{x\sqrt{2}}$

$\Rightarrow \frac{\pi}{2\sqrt{2}} = \frac{\pi}{x\sqrt{2}}$

$\Rightarrow x = 2$



Question70

Given below are two statements : one is labelled as Assertion A and the other is labelled as Reason R.

Assertion A : When a body is projected at an angle 45°, it's range is maximum.
Reason R : For maximum range, the value of sin 2θ should be equal to one.
In the light of the above statements, choose the correct answer from the options given below :
[6-Apr-2023 shift 1]

Options:

A. Both A and R are correct but R is NOT the correct explanation of A

B. A is false but R is true

C. Both A and R are correct and R is the correct explanation of A

D. A is true but R is false

Answer: C

Solution:

Solution:

For a ground to ground projectile, Horizontal range is given by $R = \frac{u^2 \sin 2\theta}{g}$ And for R_{max}, $\sin 2\theta$ must be maximum.

Question71

A child of mass 5 kg is going round a merry-go-round that makes 1 rotation in 3.14 s. The radius of the merrygo-round is 2m. The centrifugal force on the child will be [6-Apr-2023 shift 2]

Options:

A. 40N

B. 100N

C. 80N

D. 50N

Answer: A

Solution:

Solution:
Given, $m = 5\,kg$, $R = 2m$
time t for 1 rev $= 3.14$ sec or π sec
θ for 1 rev $= 2\pi$ rad
Therefore $\omega = \frac{\theta}{t} = \frac{2\pi}{\pi} = 2\,rad/s$
centrifugal force $F = mR\omega^2$
or $F = 5 \times 2 \times 2^2 = 40N$

Question72

Two projectiles A and B are thrown with initial velocities of 40m/ s and 60m/ s at angles 30° and 60° with the horizontal respectively. The ratio of their ranges respectively is ($g = 10m/s^2$)
[8-Apr-2023 shift 1]

Options:

A. $2 : \sqrt{3}$

B. $\sqrt{3} : 2$

C. 4 : 9

D. 1 : 1

Answer: C

Solution:

Solution:

$$R = \frac{u^2 \sin 2\theta}{g}$$

$\{u_1 = 40\text{m/s}, \theta_1 = 30^\circ, u_2 = 60\text{m/s}, \theta_2 = 60^\circ\}$

$$\frac{R_1}{R_2} = \left(\frac{u_1}{u_2}\right)^2 \frac{\sin 2\theta_1}{\sin 2\theta_2}$$

$$\frac{R_1}{R_2} = \left(\frac{40}{60}\right)^2 \times \frac{\sin 60^\circ}{\sin 120^\circ} \Rightarrow \frac{R_1}{R_2} = \frac{4}{9}$$

Question73

The trajectory of projectile, projected from the ground is given by $y = x - \frac{x^2}{20}$. Where x and y are measured in meter. The maximum height attained by the projectile will be.
[8-Apr-2023 shift 2]

Options:

A. 10m

B. 200m

C. $10\sqrt{2}$m

D. 5m

Answer: D

Solution:

Solution:

$$y = x - \frac{x^2}{20}$$

$$\left(\frac{dy}{dx}\right) = 1 - \frac{x}{10} \text{ for } y_{max}; \frac{dy}{dx} = 0$$

$$x = 10$$

$$y_{max} = 10 - \frac{100}{20} = 5\text{m}$$

Question74

The range of the projectile projected at an angle of 15° with horizontal is 50m. If the projectile is projected with same velocity at an angle of 45° with horizontal, then its range will be
[10-Apr-2023 shift 1]

Options:

A. $100\sqrt{2}$m

B. 50m

C. 100m

D. $50\sqrt{2}$m

Answer: C

Solution:

Solution:

So $R = \frac{u^2 \sin(2 \times 15)}{g} = \frac{u^2}{2g} =$ So $\Rightarrow \frac{u^2}{g} = 100$

$R' = \frac{u^2 \sin(2 \times 45)}{g} = \frac{u^2}{g} = 100\text{m}$

Question75

Two projectiles are projected at 30° and 60° with the horizontal the same speed. The ratio of the maximum height attained by the two projectiles respectively is: [10-Apr-2023 shift 2]

Options:

A. $2 : \sqrt{3}$

B. $1 : \sqrt{3}$

C. $\sqrt{3} : 1$

D. 1 : 3

Answer: D

Solution:

Solution:

In projectile motion, $H_{many} = \frac{u^2 \sin^2\theta}{2g}$

at $\theta = 30°$, $H_1 = \frac{u^2 \sin^2 30°}{2g}$

at $\theta = 60°$, $H_2 = \frac{u^2 \sin^2 60°}{2g}$

$\frac{H_1}{H_2} = \frac{\sin^2 30°}{\sin^2 60°} = \frac{\left(\frac{1}{2}\right)}{\left(\frac{\sqrt{3}}{2}\right)^2} = \frac{1}{3}$

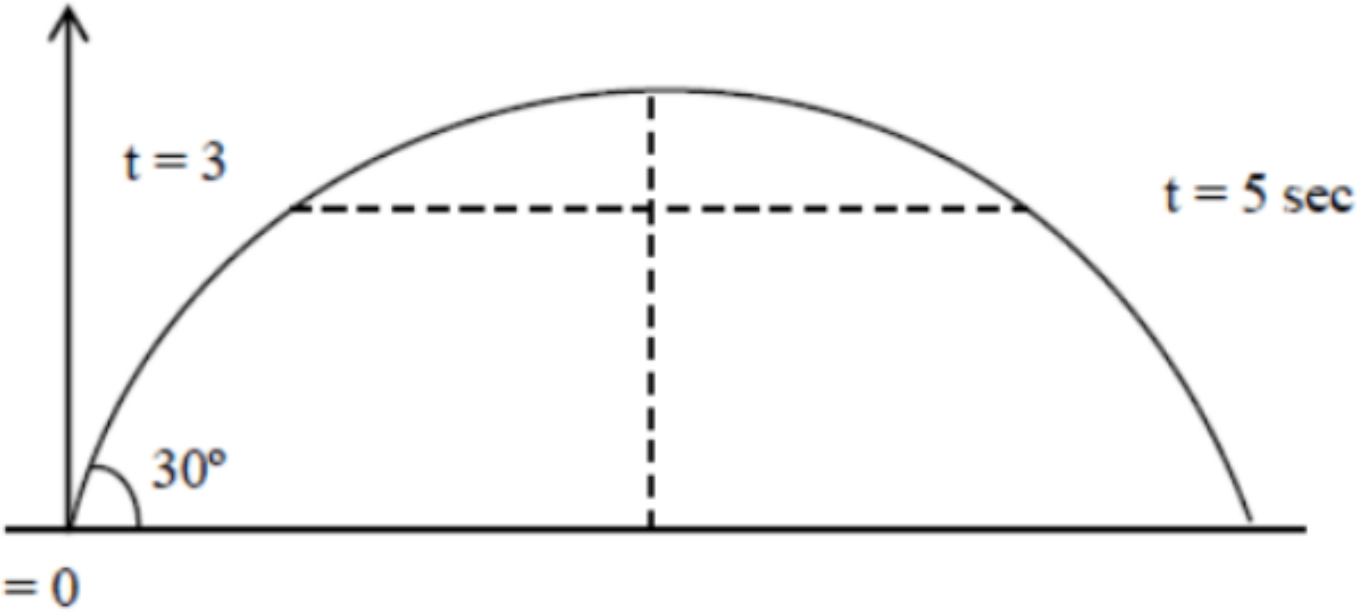
Question76

A projectile fired at 30° to the ground is observed to be at same height at time 3 s and 5 s after projection, during its flight. The speed of projection of the projectile is _____ ms^{-1}.
(Given g = 10ms^{-2})
[11-Apr-2023 shift 1]

Answer: 80

Solution:

Solution:
Time of flight $= 5 + 3 = 8$ sec.



Now, $T = \frac{2u\sin\theta}{g}$

$8 = \frac{2u \cdot \sin 30^\circ}{10}$

$\Rightarrow u = 80 m/sec$

Ans.

Question77

A projectile is projected at 30° from horizontal with initial velocity 40ms^{-1}. The velocity of the projectile at t = 2 s from the start will be :
(Given g = 10m/s^2)
[11-Apr-2023 shift 2]

Options:

A. Zero

B. $20\sqrt{3}ms^{-1}$

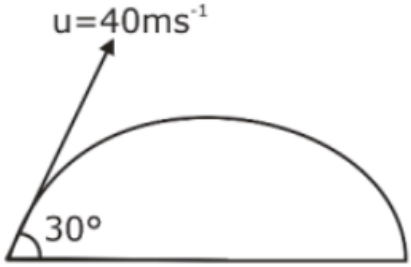
C. $40\sqrt{3}ms^{-1}$

D. $20ms^{-1}$

Answer: B

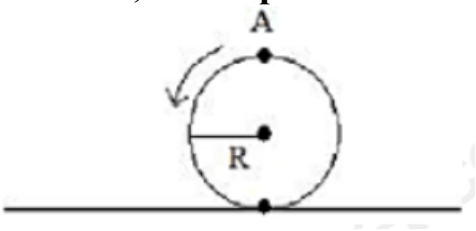
Solution:

Solution:
$U_x = 40\cos 30 = 20\sqrt{3}$
$U_y = 40\sin 30 = 20$
$Vx = 20\sqrt{3}$
$V_y = u_y - gt = 20 - 10 \times 2 = 0$
$V = \sqrt{v_x^2 + v_y^2} = 20\sqrt{3} = ms^{-1}$



Question78

A disc is rolling without slipping on a surface. The radius of the disc is R. At t = 0, the top most point on the disc is A as shown in figure. When the disc completes half of its rotation, the displacement of point A from its initial position is



[13-Apr-2023 shift 1]

Options:

A. $2R\sqrt{(1+4\pi^2)}$

B. $R\sqrt{(\pi^2+4)}$

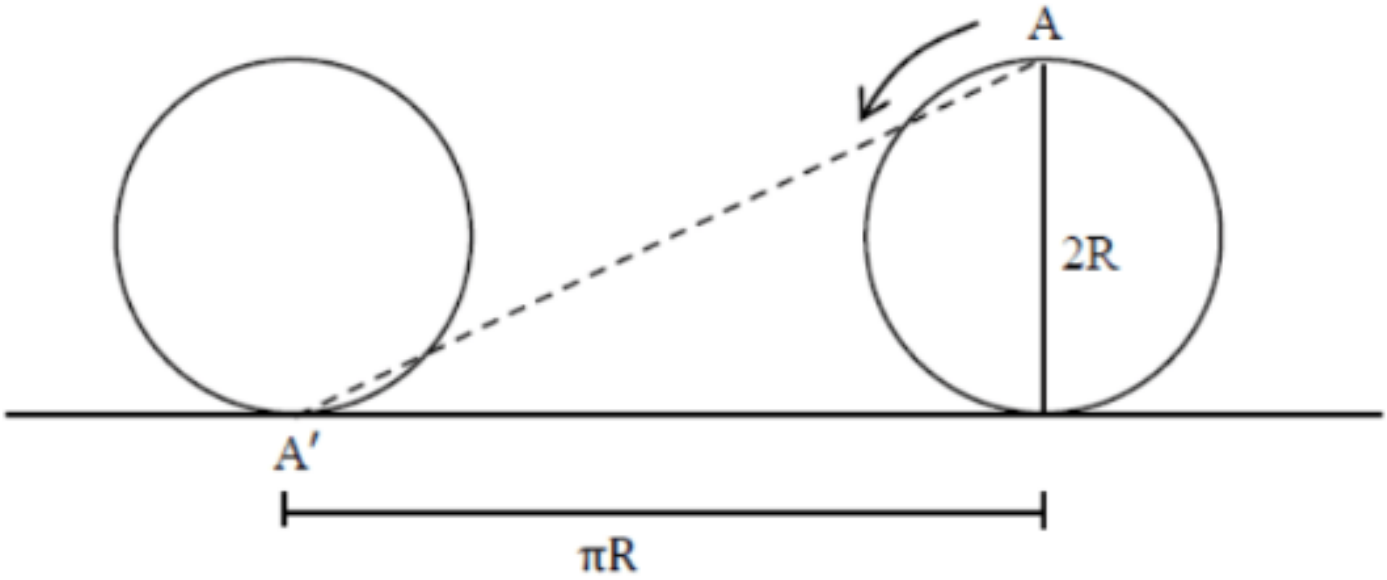
C. 2R

D. $R\sqrt{(\pi^2+1)}$

Answer: B

Solution:

Solution:



Displacement $= A'A$

$A'A = \sqrt{(\pi R)^2 + (2R)^2}$

$A'A = R\sqrt{\pi^2 + 4}$

Question79

A vehicle of mass 200 kg is moving along a levelled curved road of radius 70m with angular velocity of 0.2 rad/ s. The centripetal force acting on the vehicle is:
[13-Apr-2023 shift 2]

Options:

A. 2800N

B. 560N

C. 2240N

D. 14N

Answer: B

Solution:

Solution:

$F_c = m\omega^2 r = 200 \times (0.2)^2 \times 70$

$= 560N$

Question80

The position of a particle related to time is given by $x = (5t^2 - 4t + 5)$m. The magnitude of velocity of the particle at t = 2 s will be :
[15-Apr-2023 shift 1]

Options:

A. $10ms^{-1}$

B. $06ms^{-1}$

C. $16ms^{-1}$

D. $14ms^{-1}$

Answer: C

Solution:

Solution:

Given, $x = (5t^2 - 4t + 5)m$

$V = \frac{dx}{dt} = 10t - 4$

$t = 2, V = 20 - 4$

$V = 16m/s$

Question81

Give below are two statements
Statement I : Area under velocity- time graph gives the distance travelled by the body in a given time.
Statement II : Area under acceleration- time graph is equal to the change in velocity- in the given time.
In the light of given statement, choose the correct answer from the options given below.
[8-Apr-2023 shift 2]

Options:

A. Both Statement I and Statement II are true.

B. Statement I is correct but Statement II is false.

C. Both Statement I and and Statement II are false.

D. Statement I is incorrect but Statement II is true.

Answer: A

Solution:

Solution:

$\vec{v} = \frac{d\vec{s}}{dt} \Rightarrow \int d\vec{s} = \int \vec{v}\, dt$

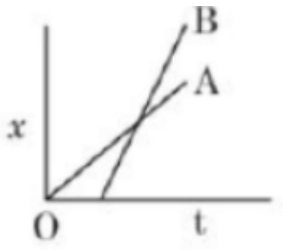
Area of $\vec{v}$ vs time gives displacement

$\vec{a} = \frac{d\vec{v}}{dt} \Rightarrow \int d\vec{v} = \int \vec{a}\, dt$

Area of $\vec{a}$ vs t graph gives change in velocity

Question82

The position-time graphs for two students A and B returning from the school to their homes are shown in figure.



(A) A lives closer to the school
(B) B lives closer to the school
(C) A takes lesser time to reach home
(D) A travels faster than B
(E) B travels faster than A
Choose the correct answer from the options given below :
[10-Apr-2023 shift 1]

Options:

A. (A) and (E) only

B. (A), (C) and (E) only

C. (B) and (E) only

D. (A), (C) and (D) only

Answer: A

Solution:

Solution:
(A) and (E) only
Slope of A = V_A
Slope of B = V_B
$(\text{slope})_B > (\text{slope})_A$
$V_B > V_A$
$\therefore t_B < t_A$

Question83

A person travels x distance with velocity v_1 and then x distance with velocity v_2 in the same direction. The average velocity of the person is v, then the relation between v, v_1 and v_2 will be.
[10-Apr-2023 shift 2]

Options:

A. $v = v_1 + v_2$

B. $\frac{1}{v} = \frac{1}{v_1} + \frac{1}{v_2}$

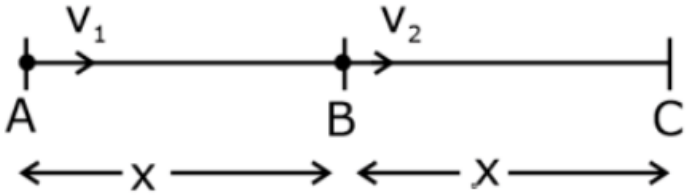
C. $\frac{2}{v} = \frac{1}{v_1} + \frac{1}{v_2}$

D. $v = \frac{v_1 + v_2}{2}$

Answer: C

Solution:

Solution:



Time taken b/wA&B $\Rightarrow t_1 = \frac{x}{v_1}$

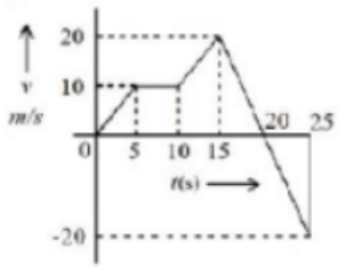
Time between b/w B&C $\Rightarrow t_2 = \frac{x}{v_2}$

Average velocity (v) = $\frac{\text{Total displacement}}{\text{Total time}} = \frac{x + x}{t_1 + t_2} = \frac{2x}{\frac{x}{v_1} + \frac{x}{v_2}}$

(v) = $\frac{2v_1v_2}{v_1 + v_2}$ or $\frac{2}{v} = \frac{1}{v_1} + \frac{1}{v_2}$

Question84

From the v − t graph shown, the ratio of distance to displacement in 25 s of motion is:



[11-Apr-2023 shift 1]

Options:

A. $\frac{3}{5}$

B. $\frac{1}{2}$

C. $\frac{5}{3}$

D. 1

Answer: C

Solution:

Solution:

Displacement = Area of graph with sign

$$\text{Displacement} = \left(\frac{1}{2}\times 10\times 5\right) + (10\times 5) + \left(\frac{1}{2}\times 5\times 30\right) + \left(\frac{1}{2}\times 5\times 20\right) - \frac{1}{2}(5)(20)$$

$$= 25 + 50 + 75 + 50 - 50$$

$$= 150\text{m}$$

Distance → Area of graph with positive value

Distance $= 25 + 50 + 75 + 50 = 250$

$$\frac{\text{Distance}}{\text{Displacement}} = \frac{250}{150} = \frac{5}{3} \quad \text{option} \rightarrow (3)$$

Question85

A ball is thrown vertically upward with an initial velocity of 150m/ s. The ratio of velocity after 3 s and 5 s is $\frac{x+1}{x}$. The value of x is _____.

{take, g = 10m/ s^2}
[12-Apr-2023 shift 1]

Options:

A. 6

B. 5

C. -5

D. 10

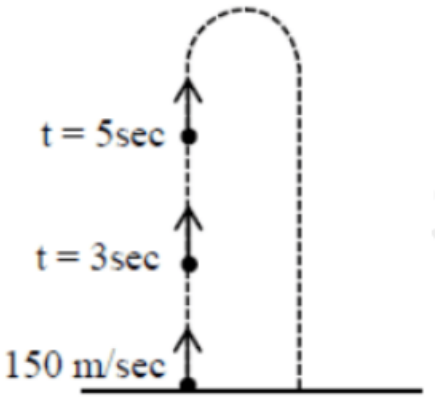
Answer: B

Solution:

Solution:

$$\text{ToF} = \frac{24}{g} = \frac{2\times 150}{10} = 30 \text{ sec}$$

$$\text{ToA} = 15 \text{ sec.}$$



$$\frac{V_1}{V_2} = \frac{u + at_1}{u + at_2}$$

$$\frac{V_1}{V_2} = \frac{150 - 10\times 3}{150 - 10\times 5} = \frac{120}{100}$$

$$\frac{V_1}{V_2} = \frac{6}{5}$$

$$x + 1 = 6$$

$$x = 5$$

Question86

Given below are two statements:
Statements I : A truck and a car moving with same kinetic energy are brought to rest by applying breaks which provide equal retarding forces. Both come to rest in equal distance.
Statements II : A car moving towards east takes a turn and moves towards north, the speed remains unchanged. The acceleration of the car is zero.
In the light of given statements, choose the most appropriate answer from the options given below
[12-Apr-2023 shift 1]

Options:

A. Statements I is correct but Statements II is incorrect.

B. Statements I is incorrect but Statements II is correct.

C. Both Statements I and Statements II are correct.

D. Both Statements I and Statements II are incorrect.

Answer: A

Solution:

Solution:
Statement-1 true
Stament-2 false

Question87

Two trains 'A' and 'B' of length ' l ' and ' 4l ' are travelling into a tunnel of length ' L ' in parallel tracks from opposite directions with velocities 108 km/h and 72 km/h, respectively. If train 'A' takes 35 s less time than train 'B' to cross the tunnel then, length ' L ' of tunnel is:
(Given L = 60l)
[13-Apr-2023 shift 1]

Options:

A. 2700m

B. 1800m

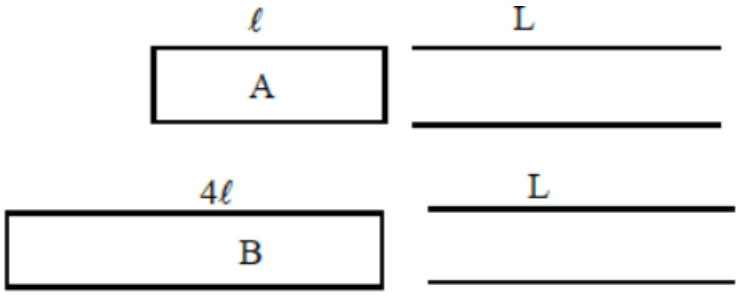
C. 1200m

D. 900m

Answer: B

Solution:

Solution:



$V_A = 108 \times \frac{5}{18} = 30\text{m/s}$

$V_B = 72 \times \frac{5}{18} = 20\text{m/s}$

$T_A = \frac{\ell + L}{30}, T_B = \frac{4\ell + L}{20}$

$T_A = T_B - 35$

$\frac{\ell + L}{30} = \frac{4\ell + L}{20} - 35$

Given, $L = 60\ell$

$\frac{61\ell}{30} = \frac{64\ell}{20} - 35$

$\frac{192\ell - 122\ell}{60} = 35$

$70\ell = 60 \times 35$

$\ell = 30\text{m}$

$L = 60\ell = 1800\text{m}$

Question88

The distance travelled by an object in time t is given by $s = (2.5)t^2$. The instantaneous speed of the object at t = 5 s will be : [13-Apr-2023 shift 2]

Options:

A. 25ms^{-1}

B. 12.5ms^{-1}

C. 5ms^{-1}

D. 62.5ms^{-1}

Answer: A

Solution:

Solution:

$S = 2.5t^2$

At, $t = 5$ sec.

$v = 5 \times 5 = 25\text{ms}^{-1}$

Question89

A passenger sitting in a train A moving at 90 km/h observes another train B moving in the opposite direction for 8 s. if the velocity of the train B is 54 km/h, then length of train B is :
[13-Apr-2023 shift 2]

Options:

A. 120m

B. 200m

C. 320m

D. 80m

Answer: C

Solution:

Solution:

$V_A = \frac{90\,km}{hr} = 25ms^{-1}$

$V_B = \frac{54\,km}{hr} = 15ms^{-1}$

$\overrightarrow{V_{BA}} = \overrightarrow{V_B} - \overrightarrow{VA} = 40ms^{-1}$

$\text{Time of crossing} = \frac{\text{Length of train}}{\text{Re lative velocity}}$

$8 = \frac{\ell}{40}$

$\ell = 8 \times 40 = 320 \text{ meter}$

Question90

From the top of a tower, a ball is thrown vertically upward which reaches the ground in 6s. A second ball thrown vertically downward from the same position with the same speed reaches the ground in 1.5s. A third ball released, from the rest from the same location, will reach the ground in s.
[24-Jun-2022-Shift-1]

Answer: 3

Solution:

Solution:
Based on the situation

$h = -ut_1 + \frac{1}{2}gt_1^2 \rightarrow$ throwing up ..... (i)

$h = ut_2 + \frac{1}{2}gt_2^2 \rightarrow$ throwing up ..... (ii)

$h = \frac{1}{2}gt^2 \rightarrow$ dropping ..... (iii)

and $0 = u(t_1 - t_2) - \frac{1}{2}g(t_1 - t_2)^2$..... (iv)

solving above equations
$t = \sqrt{t_1 t_2}$
$\Rightarrow t = \sqrt{6 \times 1.5} = 3s$

Question91

An object of mass 5 kg is thrown vertically upwards from the ground. The air resistance produces a constant retarding force of 10N throughout the motion. The ratio of time of ascent to the time of descent will be equal to : [Use $g = 10ms^{-2}$]. [24-Jun-2022-Shift-2]

Options:

A. 1 : 1

B. $\sqrt{2} : \sqrt{3}$

C. $\sqrt{3} : \sqrt{2}$

D. 2 : 3

Answer: B

Solution:

Solution:
Let time taken to ascent is t_1 and that to descent is t_2. Height will be same so
$H = \frac{1}{2} \times 12 t_1^2 = \frac{1}{2} \times 8 t_2^2$
$\Rightarrow \frac{t_1}{t_1} = \frac{\sqrt{2}}{\sqrt{3}}$

Question92

Two buses P and Q start from a point at the same time and move in a straight line and their positions are represented by $X_P(t) = \alpha t + \beta t^2$ and $X_Q(t) = f t - t^2$ At what time, both the buses have same velocity? [25-Jun-2022-Shift-2]

Options:

A. $\frac{\alpha - f}{1 + \beta}$

B. $\frac{\alpha + f}{2(\beta - 1)}$

C. $\frac{\alpha + f}{2(1 + \beta)}$

D. $\frac{f - \alpha}{2(1 + \beta)}$

Answer: D

Solution:

Solution:

$X_P = \alpha t + \beta t^2$

$X_Q = f t - t^2$

$\therefore V_P = \alpha + 2\beta t$

$V_Q = f - 2t$

$\because V_P = V_Q$

$\Rightarrow \alpha + 2\beta t = f - 2t$

$\Rightarrow t = \frac{f - \alpha}{2(1 + \beta)}$

Question93

A person is standing in an elevator. In which situation, he experiences weight loss? [26-Jun-2022-Shift-1]

Options:

A. When the elevator moves upward with constant acceleration

B. When the elevator moves downward with constant acceleration

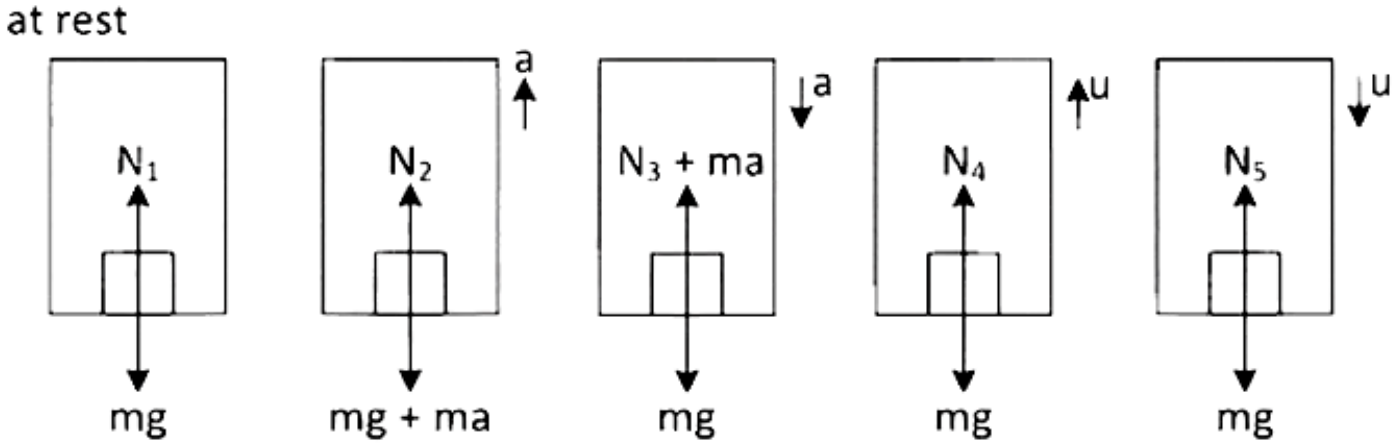
C. When the elevator moves upward with uniform velocity

D. When the elevator moves downward with uniform velocity

Answer: B

Solution:

Solution:



$N_1 = mg$

$N_2 = mg + ma$

$N_3 = mg - ma$

$N_4 = mg$

$N_5 = mg$

Question94

An object is thrown vertically upwards. At its maximum height, which of the following quantity becomes zero?
[26-Jun-2022-Shift-1]

Options:

A. Momentum

B. Potential Energy

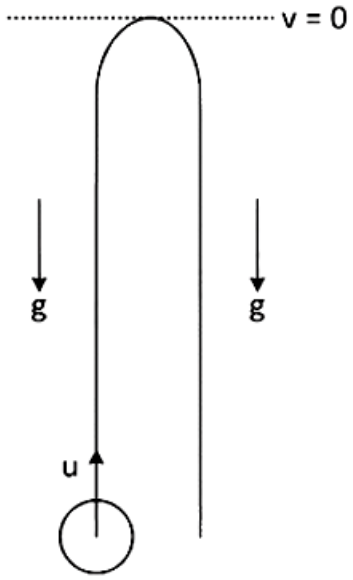
C. Acceleration

D. Force

Answer: A

Solution:

Solution:



At maximum height it's velocity is zero. So momentum (mv) will be zero.

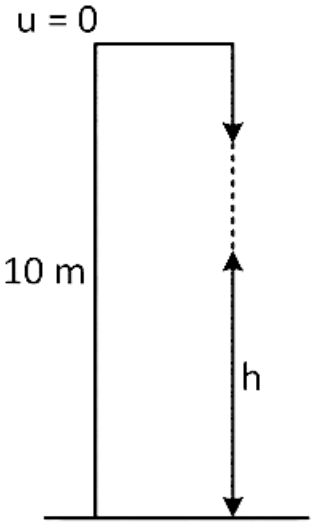
Question95

A ball of mass 0.5 kg is dropped from the height of 10m. The height, at which the magnitude of velocity becomes equal to the magnitude of acceleration due to gravity, is ____m. [Use g = 10 .m/s^2]
[26-Jun-2022-Shift-1]

Answer: 5

Solution:

Solution:



Let at h height its velocity becomes $10\mathrm{m/s}$ (as given in question)

$\Rightarrow v^2 - u^2 = 2(-10) \times (-h)$

$\Rightarrow v^2 = 20h$

$\Rightarrow 100 = 20h$

$\Rightarrow h = 5\mathrm{m}$

$h' = 10 - 5 = 5\mathrm{m}$

Question96

A ball is projected vertically upward with an initial velocity of $50\mathrm{ms}^{-1}$ at t = 0 s. At t = 2s, another ball is projected vertically upward with same velocity. At t = _____s, second ball will meet the first ball ($g = 10\mathrm{ms}^{-2}$).
[26-Jun-2022-Shift-2]

Answer: 6

Solution:

Solution:
Let they meet at $t = t$
So first ball gets t sec.
&2 nd gets $(t-2)$ sec. \& they will meet at same height

$h_1 = 50t - \frac{1}{2}gt^2$

$h_2 = 50(t-2) - \frac{1}{2}g(t-2)^2$

$h_1 = h_2$

$50t - \frac{1}{2}gt^2 = 50(t-2) - \frac{1}{2}g(t-2)^2$

$100 = \frac{1}{2}g[t^2 - (t-2)^2]$

$100 = \frac{10}{2}[4t-4]$

$5 = t - 1$

$t = 6\ \mathrm{sec}$.

Question97

A man of 60 kg is running on the road and suddenly jumps into a stationary trolly car of mass 120 kg. Then, the trolly car starts moving with velocity $2ms^{-1}$. The velocity of the running man was _____ms^{-1}, when he jumps into the car.
[28-Jun-2022-Shift-1]

Answer: 6

Solution:

Solution:
Taking the system as man and trolley and using conservation of linear momentum.
$60 \times v = (60 + 120) \times 2$
$\Rightarrow v = 6m/s$

Question98

Velocity (v) and acceleration (a) in two systems of units 1 and 2 are related as $v_2 = \frac{n}{m^2}v_1$ and $a_2 = \frac{a_1}{mn}$ respectively. Here m and n are constants. The relations for distance and time in two systems respectively are:
[28-Jun-2022-Shift-2]

Options:

A. $\frac{n^3}{m^3}L_1 = L_2$ and $\frac{n^2}{m}T_1 = T_2$

B. $L_1 = \frac{n^4}{m^2}L_2$ and $T_1 = \frac{n^2}{m}T_2$

C. $L_1 = \frac{n^2}{m}L_2$ and $T_1 = \frac{n^4}{m^2}T_2$

D. $\frac{n^2}{m}L_1 = L_2$ and $\frac{n^4}{m^2}T_1 = T_2$

Answer: A

Solution:

Solution:
$[L] = \frac{[v^2]}{[a]}$

so $\frac{[v_2]^2}{[a_2]} = \frac{\left[\frac{n}{m^2}v_1\right]^2}{\left[\frac{a_1}{m_n}\right]}$

$\frac{[v_2]^2}{[a_2]} = \frac{n^3}{m^3}\frac{[v_1]^2}{[a_1]}$

or $[L_2] = \frac{n^3}{m^3}[L_1]$

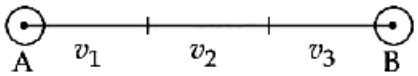
Similarly,

$[T] = \frac{[v]}{[a]}$

So, $[T_2] = \frac{n^2}{m}[T_1]$

Question99

A car covers AB distance with first one-third at velocity $v_1 ms^{-1}$, second one-third at $v_2 ms^{-1}$ and last one-third at v_3 ms^{-1}. If $v_3 = 3v_1$, $v_2 = 2v_1$ and $v_1 = 11 ms^{-1}$ then the average velocity of the car is _____ms^{-1}



[28-Jun-2022-Shift-2]

Answer: 18

Solution:

Solution:

$v_{mean} = \frac{3v_1v_2v_3}{v_1v_2 + v_2v_3 + v_3v_1}$

$= \frac{3 \times 11 \times 22 \times 33}{11 \times 22 + 22 \times 33 + 33 \times 11}$

$= 18 m/sec$

Question100

Two balls A and B are placed at the top of 180m tall tower. Ball A is released from the top at t = 0s. Ball B is thrown vertically down with an initial velocity 'u' at t = 2s. After a certain time, both balls meet 100m above the ground. Find the value of ' u ' in ms^{-1} . [. use .g = $10 ms^{-2}$] :
[29-Jun-2022-Shift-1]

Options:

A. 10

B. 15

C. 20

D. 30

Answer: D

Solution:

Solution:
Let us assume that they meet at $t = t_0$

$A : 80 = \frac{1}{2}gt_0^2 \ldots\ldots$ (i)

$B : 80 = u(t_0 - 2) + \frac{1}{2}g(t_0 - 2)^2$

From (i), $t_0 = 4$

$\Rightarrow 80 = 2u + 5(2)^2$
$\Rightarrow u = 30 m/s$

Question101

A small toy starts moving from the position of rest under a constant acceleration. If it travels a distance of 10m in ts, the distance travelled by the toy in the next ts will be : [29-Jun-2022-Shift-2]

Options:

A. 10m

B. 20m

C. 30m

D. 40m

Answer: C

Solution:

Solution:
$u = 0$, Say acceleration is a
Fort s $10 = \frac{1}{2}at^2$
For 2t s
$10 + x = \frac{1}{2}a(2t)^2$
$\frac{10 + x}{10} = \frac{4}{1}$
$x = 30m$

Question102

A projectile is projected with velocity of 25m/s at an angle θ with the horizontal. After t seconds its inclination with horizontal becomes zero. If R represents horizontal range of the projectile, the value of θ will be : [use $g = 10 m/s^2$] [24-Jun-2022-Shift-1]

Options:

A. $\frac{1}{2}\sin^{-1}\left(\frac{5t^2}{4R}\right)$

B. $\frac{1}{2}\sin^{-1}\left(\frac{4R}{5t^2}\right)$

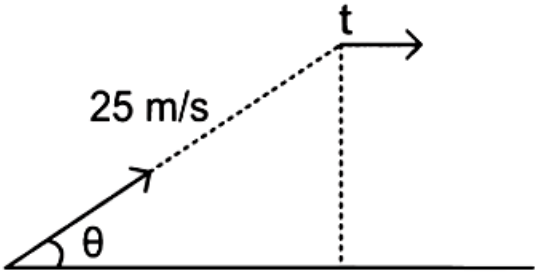
C. $\tan^{-1}\left(\frac{4t^2}{5R}\right)$

D. $\cot^{-1}\left(\frac{R}{20t^2}\right)$

Answer: D

Solution:

Solution:



$t = \frac{25\sin\theta}{g}$

and, $R = \frac{(25)^2(2\sin\theta\cos\theta)}{g}$

$\Rightarrow R = \frac{25\times 25\times 2}{g}\times\frac{gt}{25}\times\cos\theta$

$\Rightarrow R = 50t\cos\theta$

$\therefore \tan\theta = \frac{gt}{25}\times\frac{50t}{R}$

$= \frac{20t^2}{R}$

$\Rightarrow \theta = \cot^{-1}\left(\frac{R}{20t^2}\right)$

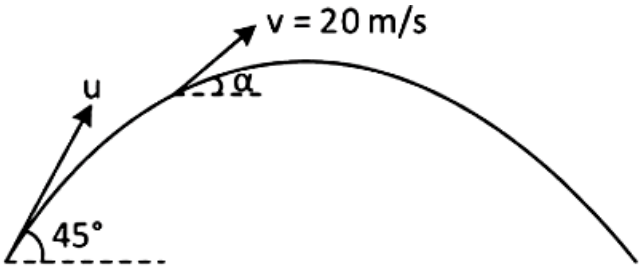
Question103

A body is projected from the ground at an angle of 45° with the horizontal. Its velocity after 2 s is 20 ms^{-1}. The maximum height reached by the body during its motion is____ m. (use g = 10ms^{-2})
[24-Jun-2022-Shift-2]

Answer: 20

Solution:

Solution:



$\Rightarrow v\cos\alpha = u\cos 45^\circ$..... (i)

&$v\sin\alpha = u\sin 45^\circ - gt$.... (ii)

Solve for u we get

$u = 20\sqrt{2}\,m/s$

$\Rightarrow H = \frac{u^2\sin^2 45^\circ}{20} = 20m$

Question104

Given below are two statements. One is labelled as Assertion A and the other is labelled as Reason R.

Assertion A: Two identical balls A and B thrown with same velocity 'u' at two different angles with horizontal attained the same range R. IF A and B reached the maximum height h_1 and h_2 respectively, then $R = 4\sqrt{h_1h_2}$

Reason R : Product of said heights.

$$h_1h_2 = \left(\frac{u^2\sin^2\theta}{2g}\right)\cdot\left(\frac{u^2\cos^2\theta}{2g}\right)$$

Choose the correct answer :

[25-Jun-2022-Shift-2]

Options:

A. Both A and R are true and R is the correct explanation of A.

B. Both A and R are true but R is NOT the correct explanation of A.

C. A is true but R is false.

D. A is false but R is true.

Answer: A

Solution:

Solution:

$h_1 = \frac{u^2\sin^2\theta}{2g}$

$h_2 = \frac{u^2\cos^2\theta}{2g}$

$\therefore\sqrt{h_1h_2} = \frac{u^2\sin\theta\cos\theta}{2g}$

$= \frac{R}{4}$

$\Rightarrow R = 4\sqrt{h_1h_2}$

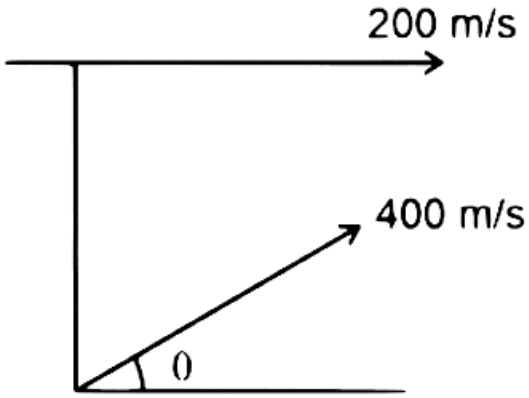
Question105

A fighter jet is flying horizontally at a certain altitude with a speed of $200ms^{-1}$. When it passes directly overhead an anti-aircraft gun, a bullet is fired from the gun, at an angle θ with the horizontal, to hit the jet. If the bullet speed is 400m/s, the value of θ will be_____°
[26-Jun-2022-Shift-1]

Answer: 60

Solution:

Solution:



To hit the jet both should have same horizontal component of velocity.
To hit the jet
$400\cos\theta = 200$
$\Rightarrow \cos\theta = \frac{1}{2}$
$\Rightarrow \theta = 60^{\circ}$

Question106

A projectile is launched at an angle ' α ' with the horizontal with a velocity $20ms^{-1}$. After 10s, its inclination with horizontal is ' β '. The value of tan β will be :
($g = 10ms^{-2}$).
[27-Jun-2022-Shift-1]

Options:

A. $\tan\alpha + 5\sec\alpha$

B. $\tan\alpha - 5\sec\alpha$

C. $2\tan\alpha - 5\sec\alpha$

D. $2\tan\alpha + 5\sec\alpha$

Answer: B

Solution:

Solution:
$v_y = 20 \times \sin\alpha - 10 \times 10$
$v_x = 20\cos\alpha$
$\therefore \tan\beta = \frac{v_y}{v_x} = \frac{20\sin\alpha - 100}{20\cos\alpha}$
$= \tan\alpha - 5\sec\alpha$

Question107

A girl standing on road holds her umbrella at 45° with the vertical to keep the rain away. If she starts running without umbrella with a speed of $15\sqrt{2}\text{kmh}^{-1}$, the rain drops hit her head vertically. The speed of rain drops with respect to the moving girl is :
[27-Jun-2022-Shift-1]

Options:

A. 30kmh^{-1}

B. $\frac{25}{\sqrt{2}}\text{kmh}^{-1}$

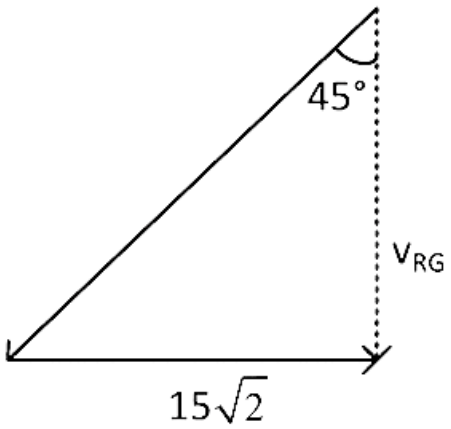
C. $\frac{30}{\sqrt{2}}\text{kmh}^{-1}$

D. 25kmh^{-1}

Answer: C

Solution:

Solution:



From graph,
$v_{RG} = 15\sqrt{2}\tan 45^\circ$
$= 15\sqrt{2}$
$= \frac{30}{\sqrt{2}}$

Question108

Motion of a particle in x-y plane is described by a set of following equations $x = 4\sin\left(\frac{\pi}{2} - \omega t\right)$ m and $y = 4\sin(\omega t)$ m. The path of the particle will be : [28-Jun-2022-Shift-1]

Options:

A. circular

B. helical

C. parabolic

D. elliptical

Answer: A

Solution:

Solution:

$x = 4\sin\left(\frac{\pi}{2} - \omega t\right)$

$= 4\cos(\omega t)$

$y = 4\sin(\omega t)$

$\Rightarrow x^2 + y^2 = 4^2$

$\Rightarrow$ The particle is moving in a circular motion with radius of 4m.

Question109

A ball is spun with angular acceleration $\alpha = 6t^2 - 2t$ where t is in second and α is in rads -2. At $t = 0$, the ball has angular velocity of 10 rads $^{-1}$ and angular position of 4 rad. The most appropriate expression for the angular position of the ball is [28-Jun-2022-Shift-2]

Options:

A. $\frac{3}{2}t^4 - t^2 + 10t$

B. $\frac{t^4}{2} - \frac{t^3}{3} + 10t + 4$

C. $\frac{2t^4}{3} - \frac{t^3}{6} + 10t + 12$

D. $2t^4 - \frac{t^3}{2} + 5t + 4$

Answer: B

Solution:

Solution:

$\alpha = \frac{d\omega}{dt} = 6t^2 - 2t$

$\int_0^{\omega} d\omega = \int_0^t (6t^2 - 2t)\, dt$

so $\omega = 2t^3 - t^2 + 10$

and $\frac{d\theta}{dt} = 2t^3 - t^2 + 10$

so $\int_4^\theta d\theta = \int_0^t (2t^3 - t^2 + 10)\, dt$

$\theta = \frac{t^4}{2} - \frac{t^3}{3} + 10t + 4$

Question110

A person can throw a ball upto a maximum range of 100m. How high above the ground he can throw the same ball?
[29-Jun-2022-Shift-2]

Options:

A. 25m

B. 50m

C. 100m

D. 200m

Answer: B

Solution:

Solution:

$R = \frac{u^2 \sin 2\theta}{g} R_{max} = \frac{u^2}{g} = 100$

$H_{max} = \frac{u^2}{2g} = \frac{100}{2} = 50m$

Question111

A ball is thrown vertically upwards with a velocity of $19.6ms^{-1}$ from the top of a tower. The ball strikes the ground after 6 s. The height from the ground up to which the ball can rise will be $\left(\frac{k}{5}\right)$ m. The value of k is (use .g = $9.8m/s^2$)
[28-Jul-2022-Shift-2]

Answer: 392

Solution:

Solution:

$t_a = \frac{u}{g} = \frac{19.6}{9.8} = 2\ s$

$t_d = 6 - 2\ s = \sqrt{\frac{2h_{max}}{g}}$

$\Rightarrow h_{max} = \frac{16 \times 9.8}{2} = \frac{392}{5}$

Question112

A car is moving with speed of 150km/h and after applying the break it will move 27m before it stops. If the same car is moving with a speed of one third the reported speed then it will stop after travelling m distance.
[25-Jul-2022-Shift-1]

Answer: 3

Solution:

Solution:

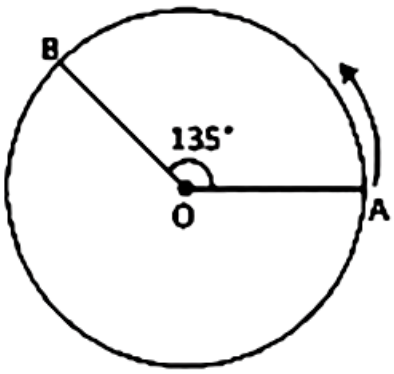
$F_R d = \frac{1}{2}mv^2$

$\frac{d_2}{d_1} = \left(\frac{v_2}{v_1}\right)^2 = \left(\frac{1}{3}\right)^2$

$d_2 = d_1 \times \frac{1}{9} = 3m$

Question113

A person moved from A to B on a circular path as shown in figure. If the distance travelled by him is 60m, then the magnitude of displacement would be:
(Given $\cos 185^\circ = -0.7$)



[25-Jul-2022-Shift-1]

Options:

A. 42m

B. 47m

C. 19m

D. 40m

Answer: B

Solution:

Solution:
Distance travelled $= 60\text{m}$
$\Rightarrow$ Angle covered $= 135^\circ$

Displacement $= 2R\sin\left(\frac{135^\circ}{2}\right)$

$= 2\left(\frac{60}{135}\times\frac{180}{\pi}\right)\left[\frac{1-\cos(135^\circ)}{2}\right]^{1/2}$

$= 2\left(\frac{80}{\pi}\right)(0.85)^{1/2}$

$\approx 47\text{m}$

Question114

A particle is moving in a straight line such that its velocity is increasing at 5ms^{-1} per meter. The acceleration of the particle is _____ms^{-2} at a point where its velocity is 20ms^{-1}.
[25-Jul-2022-Shift-2]

Answer: 100

Solution:

Solution:
$\frac{dv}{dx} = 5\text{ms}^{-1}/\text{m}$
Acceleration of particle when $v = 20\text{m}/\text{s}$
$a = v\frac{dv}{dx} = 20(5)\text{m}/\text{s}^2 = 100\text{m}/\text{s}^2$

Question115

Two projectiles thrown at 30° and 45° with the horizontal respectively, reach the maximum height in same time. The ratio of their initial velocities is :
[26-Jul-2022-Shift-1]

Options:

A. $1 : \sqrt{2}$

B. 2 : 1

C. $\sqrt{2} : 1$

D. 1 : 2

Answer: C

Solution:

Solution:

$\because t_a = \frac{u \sin\theta}{g}$

$\Rightarrow \frac{u_1 \sin(30^\circ)}{g} = \frac{u_1 \sin(45^\circ)}{g}$

$\Rightarrow \frac{u_1}{u_2} = \frac{\frac{1}{\sqrt{2}}}{\frac{1}{2}} = \frac{\sqrt{2}}{1}$

Question116

Two projectiles are thrown with same initial velocity making an angle of 45° and 30° with the horizontal respectively. The ratio of their respective ranges will be : [26-Jul-2022-Shift-2]

Options:

A. $1 : \sqrt{2}$

B. $\sqrt{2} : 1$

C. $2 : \sqrt{3}$

D. $\sqrt{3} : 2$

Answer: C

Solution:

Solution:

Let projection speed is u

$R_1 = \frac{u^2 \text{Sin}(90^\circ)}{g}; R_2 = \frac{u^2 \sin(60^\circ)}{g}$

$\frac{R_1}{R_2} = \frac{2}{\sqrt{3}}$

Question117

A ball is thrown up vertically with a certain velocity so that, it reaches a maximum height h. Find the ratio of the times in which it is at height $\frac{h}{3}$ while going up and

coming down respectively.
[29-Jul-2022-Shift-1]

Options:

A. $\frac{\sqrt{2}-1}{\sqrt{2}+1}$

B. $\frac{\sqrt{3}-\sqrt{2}}{\sqrt{3}+\sqrt{2}}$

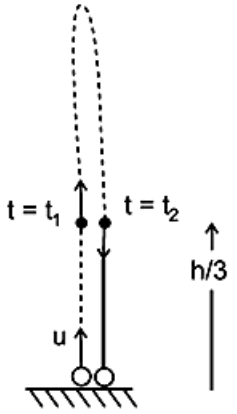
C. $\frac{\sqrt{3}-1}{\sqrt{3}+1}$

D. $\frac{1}{3}$

Answer: B

Solution:

Solution:



Max. Height $= h = \frac{u^2}{2g}$

$\Rightarrow u = \sqrt{2gh}$

$S = ut + \frac{1}{2}aat^2$

$\frac{h}{3} = \sqrt{2gh}t + \frac{1}{2}(-g)t^2$

$\frac{gt^2}{2} - \sqrt{2ght} + \frac{h}{3} = 0$ (. Roots are $t_1 \& t_2$)

$\frac{t_2}{t_1} = \frac{\sqrt{2gh} + \sqrt{2gh - 4 \times \frac{g}{2} \times \frac{h}{3}}}{\sqrt{2gh} - \sqrt{2gh - 4 \times \frac{g}{2} \times \frac{h}{3}}} = \frac{\sqrt{2gh} + \sqrt{\frac{4gh}{3}}}{\sqrt{2gh} - \sqrt{\frac{4gh}{3}}} = \frac{\sqrt{3}+\sqrt{2}}{\sqrt{3}-\sqrt{2}}$

Question118

If $t = \sqrt{x} + 4$, then $\left(\frac{dx}{dt}\right)_{t=4}$ is :

[29-Jul-2022-Shift-1]

Options:

A. 4

B. zero

C. 8

D. 16

Answer: B

Solution:

Solution:
$t = \sqrt{x} + 4$
$\Rightarrow x = (t-4)^2 = t^2 - 8t + 16$
$\Rightarrow \frac{dx}{dt} = 2t - 8$
$\Rightarrow \frac{dx}{dt}\Big|_{t=4} = 2 \times 4 - 8 = 0$

Question119

A juggler throws balls vertically upwards with same initial velocity in air. When the first ball reaches its highest position, he throws the next ball. Assuming the juggler throws n balls per second, the maximum height the balls can reach is [29-Jul-2022-Shift-2]

Options:

A. $g/2n$

B. g/n

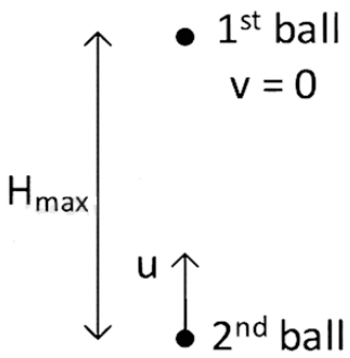
C. $2gn$

D. $g/2n^2$

Answer: D

Solution:

Solution:
The juggler throws n balls per second.
$\therefore$ Interval between balls $= \frac{1}{n}$ seconds



At maximum height velocity of first ball $v = 0$
Juggler throws all balls with same initial velocity $= u$
For 1 st ball,
$u_1 = u, v_1 = 0, a = -g, S = H_{max}$
Using formula,
$v^2 = u^2 + 2as$
$0 = u^2 - 2gH_{max}$
$\Rightarrow H_{max} = \frac{u^2}{2g} \ldots\ldots (1)$
And using formula,
$v = u + at$
$\Rightarrow 0 = u - gt$
$\Rightarrow t = \frac{u}{g}$
$\therefore$ Time taken by ball 1 to reach maximum height $(H_{max}) = \frac{u}{g}$
According to the question,
$t = \frac{1}{n}$
$\Rightarrow \frac{u}{g} = \frac{1}{n}$
$\Rightarrow u = \frac{g}{n} \ldots\ldots (2)$
Putting value of u in equation (1), we get
$H_{max} = \frac{\left(\frac{g}{n}\right)^2}{2g}$
$= \frac{g^2}{2n^2 g}$
$= \frac{g}{2n^2}$

Question120

A ball is released from a height h. If t_1 and t_2 be the time required to complete first half and second half of the distance respectively. Then, choose the correct relation between t_1 and t_2.

[29-Jul-2022-Shift-2]

Options:

A. $t_1 = (\sqrt{2})t_2$

B. $t_1 = (\sqrt{2} - 1)t_2$

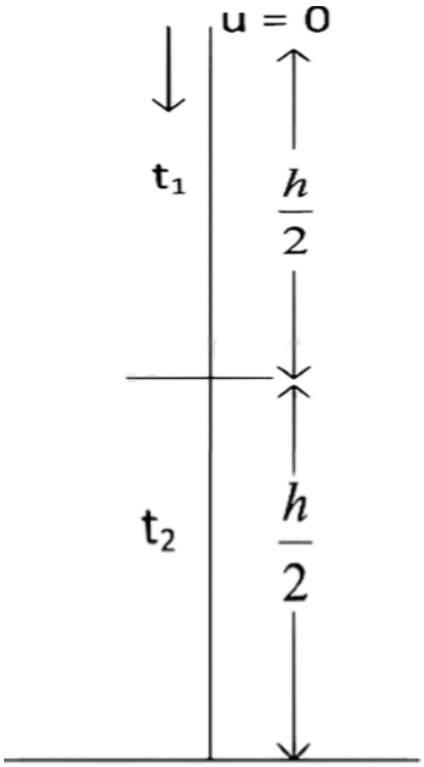
C. $t_2 = (\sqrt{2} + 1)t_1$

D. $t_2 = (\sqrt{2} - 1)t_1$

Answer: D

Solution:

Solution:



For first $\frac{h}{2}$ distance,

$\frac{h}{2} = \frac{1}{2}gt_1^2$

$\Rightarrow h = gt_1^2$

For total distance h,

$h = \frac{1}{2}g(t_1 + t_2)^2$

$\Rightarrow gt_1^2 = \frac{1}{2}g(t_1 + t_2)^2$

$\Rightarrow 2t_1^2 = (t_1 + t_2)^2$

$\Rightarrow \sqrt{2}t_1 = t_1 + t_2$

$\Rightarrow (\sqrt{2} - 1)t_1 = t_2$

Question121

A ball is projected from the ground with a speed $15ms^{-1}$ at an angle θ with horizontal so that its range and maximum height are equal, then 'tan θ' will be equal to: [25-Jul-2022-Shift-2]

Options:

A. $\frac{1}{4}$

B. $\frac{1}{2}$

C. 2

D. 4

Answer: D

Solution:

Solution:
$\because \tan\theta = \frac{4H}{R}$
$\Rightarrow \tan\theta = 4 \times 1$
$\Rightarrow \tan\theta = 4$

Question122

If the initial velocity in horizontal direction of a projectile is unit vector $\hat{i}$ and the equation of trajectory is y = 5x(1 − x). The y component vector of the initial velocity is _____ $\hat{j}$. Take .g = 10m/s^2)
[26-Jul-2022-Shift-1]

Answer: 5

Solution:

Solution:
$y = 5x - 5x^2$
$y = x\tan\theta - \frac{1}{2}\frac{gx^2}{v^2}$
$\tan\theta = 5 = \frac{u_y}{u_x}$
$\Rightarrow u_y = 5$

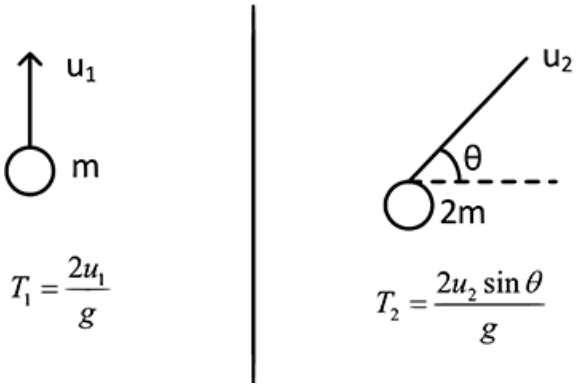
Question123

A ball of mass m is thrown vertically upward. Another ball of mass 2m is thrown at an angle θ with the vertical. Both the balls stay in air for the same period of time. The ratio of the heights attained by the two balls respectively is $\frac{1}{x}$. The value of x is _____.
[27-Jul-2022-Shift-1]

Answer: 1

Solution:

Solution:



$T_1 = \frac{2u_1}{g}$ | $T_2 = \frac{2u_2 \sin\theta}{g}$

$\therefore u_1 = u_2 \sin\theta$

$$\frac{H_1}{H_2} = \frac{\frac{u_1^2}{2g}}{u_2^2 \frac{\sin^2\theta}{2g}}$$

$$= \left(\frac{u_1}{u_2 \sin\theta}\right)^2 = 1$$

Question124

A body of mass 10 kg is projected at an angle of 45° with the horizontal. The trajectory of the body is observed to pass through a point (20, 10). If T is the time of flight, then its momentum vector, at time t = $\frac{T}{\sqrt{2}}$, is [Take .g = 10m/s^2] _____.

[27-Jul-2022-Shift-2]

Options:

A. $100\hat{i} + (100\sqrt{2} - 200)\hat{j}$

B. $100\sqrt{2}\hat{i} + (100 - 200\sqrt{2})\hat{j}$

C. $100\hat{i} + (100 - 200\sqrt{2})\hat{j}$

D. $100\sqrt{2}\hat{i} + (100\sqrt{2} - 200)\hat{j}$

Answer: D

Solution:

Solution:
m = 10 kg
$\theta = 45^\circ$

$$y = x\tan\theta\left(1 - \frac{x}{R}\right)$$

$$\Rightarrow 10 = 20\left(1 - \frac{20}{R}\right)$$

$\Rightarrow R = 40$

$$40 = \frac{u^2}{10} \Rightarrow u = 20$$

$$\Rightarrow T = \frac{20 \times 20 \times \frac{1}{\sqrt{2}}}{10} = \frac{4}{\sqrt{2}}s \Rightarrow t = 2s$$

at $t = 2,\ \vec{v} = \left(10\sqrt{2}\hat{i}\right) + (10\sqrt{2} - 2 \times 10)$

$\Rightarrow \vec{p} = 10\left[10\sqrt{2}\hat{i} + (10\sqrt{2} - 20)\hat{j}\right]$

$= 100\sqrt{2}\hat{i} + (100\sqrt{2} - 200)\hat{j}$

Question125

A NCC parade is going at a uniform speed of 9 km/h under a mango tree on which a monkey is sitting at a height of 19.6m. At any particular instant, the monkey drops a mango. A cadet will receive the mango whose distance from the tree at time of drop is: (Given $g - 9.8m/s^2$)
[28-Jul-2022-Shift-1]

Options:

A. 5m

B. 10m

C. 19.8m

D. 24.5m

Answer: A

Solution:

Solution:

$H = \frac{1}{2}gt^2$

$19.6 = 4.9t^2$

$t = 2$ sec

$D = 9 \times \frac{5}{18} \times 2 = 5m$

Question126

At time t = 0 a particle starts travelling from a height $7\hat{z}$ cm in a plane keeping z coordinate constant. At any instant of time it's position along the $\hat{x}$ and $\hat{y}$ directions are defined as 3t and $5t^3$ respectively. At t = 1 s acceleration of the particle will be
[28-Jul-2022-Shift-2]

Options:

A. $-30\hat{y}$

B. $30\hat{y}$

C. $3\hat{x} + 15\hat{y}$

D. $3\hat{x} + 15\hat{y} + 7\hat{z}$

Answer: B

Solution:

Solution:
$x = 3t \Rightarrow a_x = 0$
$y = 5t^3 \Rightarrow a_y = 30t$
$\vec{a}(t = 1) = 30\hat{y}$

Question127

A ball is projected with kinetic energy E , at an angle of 60° to the horizontal. The kinetic energy of this ball at the highest point of its flight will become :
[29-Jul-2022-Shift-1]

Options:

A. Zero

B. $\frac{E}{2}$

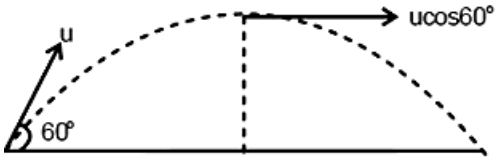
C. $\frac{E}{4}$

D. E

Answer: C

Solution:

Solution:



$E = \frac{1}{2}mu^2$
At Highest point, Velocity $V = u\cos 60^\circ = \frac{u}{2}$
$\therefore$ K.E at topmost point $= \frac{1}{2}m\left(\frac{u}{2}\right)^2 = \frac{E}{4}$

Question128

An object is projected in the air with initial velocity u at an angle θ. The projectile motion is such that the horizontal range R, is maximum. Another object is projected in the air with a horizontal range half of the range of first object. The initial velocity remains same in both the case. The value of the angle of projection, at which the second object is projected, will be _____ degree.
[29-Jul-2022-Shift-1]

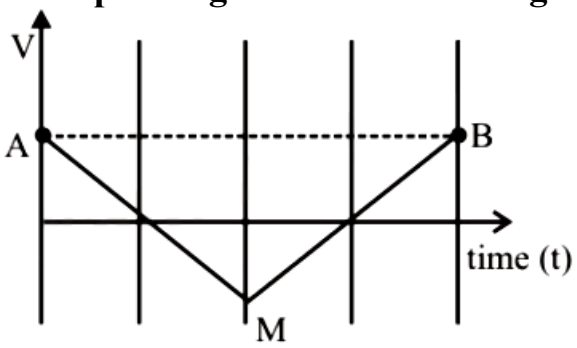
Answer: 15

Solution:

Solution:
$\theta = 45^\circ$
$R_1 = \frac{R}{2}$
$\frac{u^2 \sin 2\theta_1}{g} = \frac{u^2 \sin(90^\circ)}{2g}$
$\Rightarrow 2\theta_1 = 30^\circ$
$\theta_1 = 15^\circ$

Question129

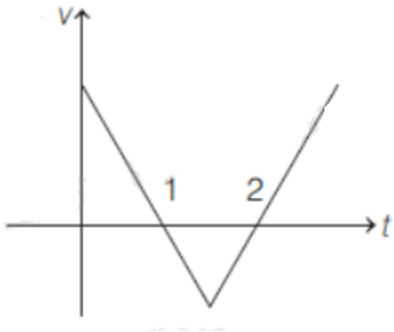
If the velocity-time graph has the shape AMB, what would be the shape of the corresponding acceleration-time graph?



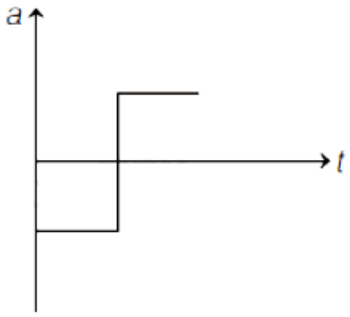
[24feb2021shift1]

Options:

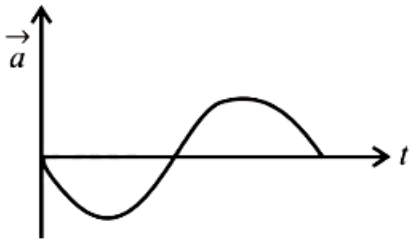
A.

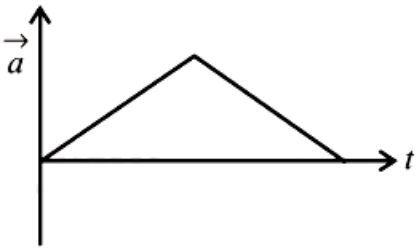


B.



C.



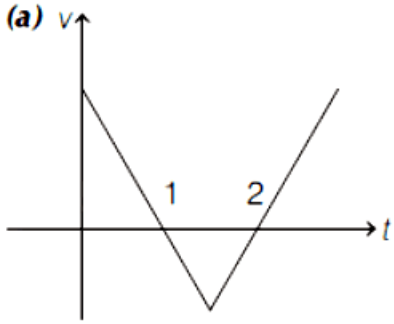


D.

Answer: B

Solution:

Solution:



From the graph for first line, the slope is negative and intercept is positive.
So, equation of line is

$v = -mt + c$

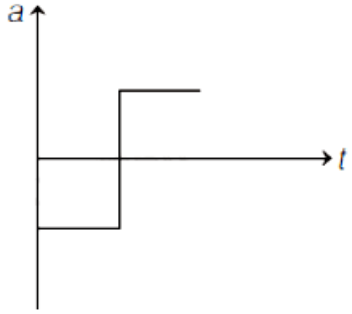
$a_1 = \frac{dv}{dt} = -m$

Similarly, for second line, the slope is positive and intercept is negative, so equation of line is

$v = mt - c$

$a_2 = \frac{dv}{dt} = m$

∴ The corresponding acceleration-time graph as shown below



Hence, option (a) is correct.

Question130

A scooter accelerates from rest for time t_1 at constant rate a_1 and then retards at constant rate a_2 for time t_2 and comes to rest. The correct value of $\frac{t_1}{t_2}$ will be
[26 Feb 2021 Shift 2]

Options:

A. $\frac{a_1 + a_2}{a_2}$

B. $\frac{a_2}{a_1}$

C. $\frac{a_1}{a_2}$

D. $\frac{a_1 + a_2}{a_1}$

Answer: B

Solution:

Solution:
According to given data;
Initial speed of scooter, $u_1 = 0 ms^{-1}$
and final speed, $v_2 = 0 ms^{-1}$
By using first equation of motion,
$v_1 = u + a_1 t_1$
$\Rightarrow v_1 = a_1 t_1 \ldots$ (i)
and for second case,
$v_2 = v_1 - a_2 t_2$
$0 = v_1 - a_2 t_2$
$v_1 = a_2 t_2 \ldots$ (ii)
On dividing Eq. (i) by Eq. (ii), we get
$v_1 / v_1 = 1 = \frac{a_1 t_1}{a_2 t_2}$
$\Rightarrow a_2 t_2 = a_1 t_1$
$\Rightarrow t_1 / t_2 = a_2 / a_1$

Question131

A stone is dropped from the top of a building. When it crosses a point 5m below the top, another stone starts to fall from a point 25m below the top. Both stones reach the bottom of building simultaneously. The height of the building is
[25 Feb 2021 Shift 2]

Options:

A. 45m

B. 25m

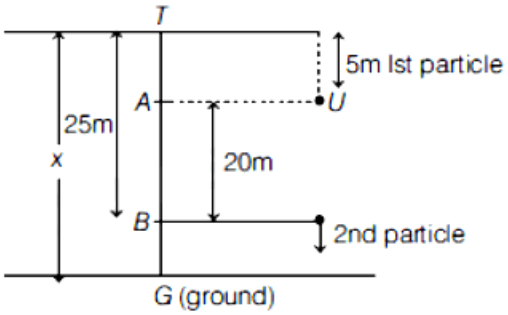
C. 35m

D. 50m

Answer: A

Solution:

Solution:
Let the total height of building be x.



$TA = 5m$
$TB = 25m$
$\therefore\ AG = x - 5$ and $BC = x - 25$
For initial conditions, from second equation of motion under gravity,
$s = ut + 1/2gt^2$
where, $g = 10ms^{-2}$
$\therefore\ 5 = 0 + 1/2 \times 10t^2 \Rightarrow t = 1s$
Now, by first equation of motion under gravity,
$v_A = u + gt$
$= 0 + 10 = 10ms^{-1}$
From second equation of motion,
$x - 5 = v_A t + 1/2gt^2$ . . . (i)
Similarly, $x - 25 = 1/2gt^2$
Put the above value in Eq. (i), we get
$x - 5 = 10t + x - 25$
$20 = 10t \Rightarrow t = 2s$
Put the value of t in Eq. (i), we get
$x - 5 = 10 \times 2 + 1/2 \times 10 \times 4$
$x - 5 = 20 + 20$
$x = 45m$

Question132

An engine of a train moving with uniform acceleration, passes the signal-post with velocity u and the last compartment with velocity v. The velocity with which middle point of the train passes the signal post is [25 Feb 2021 Shift 1]

Options:

A. $\sqrt{\frac{v^2+u^2}{2}}$

B. $\frac{v-u}{2}$

C. $\frac{u+v}{2}$

D. $\sqrt{\frac{v^2-u^2}{2}}$

Answer: A

Solution:

Solution:
Given, initial speed of engine $= u$
Speed of engine last compartment $= v$
Let the length of train be I and the speed of mid-point of train be v'.
Using third equation of motion,
$v^2 = u^2 + 2as$
$\Rightarrow \; v'^2 = u^2 + 2al \,/\, 2$
$\Rightarrow \; v'^2 - u^2 = al \;\ldots$ (i)
Also, $\quad v^2 - u^2 = 2al \Rightarrow a = \frac{v^2-u^2}{2l}$
Substituting the value of a in Eq. (i), we get
$v'^2 - u^2 \;=\; \frac{v^2-u^2}{2l} \cdot l = \frac{v^2-u^2}{2}$
$\Rightarrow \; v' \;=\; \sqrt{\frac{v^2-u^2}{2} + u^2} = \sqrt{\frac{v^2+u^2}{2}}$

Question133

The trajectory of a projectile in a vertical plane is $y = \alpha x - \beta x^2$, where α and β are constants and x and y are respectively the horizontal and vertical distances of the projectile from the point of projection. The angle of projection θ and the maximum height attained H are respectively given by
[26 Feb 2021 Shift 2]

Options:

A. $\tan^{-1}\alpha, \; \frac{\alpha^2}{4\beta}$

B. $\tan^{-1}\beta, \; \frac{\alpha^2}{2\beta}$

C. $\tan^{-1}\alpha, \; \frac{4\alpha^2}{\beta}$

D. $\tan^{-1}\left(\frac{\beta}{\alpha}\right), \; \frac{\alpha^2}{\beta}$

Answer: A

Solution:

Solution:
Given, equation of trajectory of projectile,
$y = \alpha x - \beta x^2 \;\ldots$ (i)
The standard equation of trajectory of projectile,
$y = x\tan\theta - \frac{gx^2}{2u^2\cos^2\theta} \;\ldots$ (ii)
Now, from Eqs. (i) and (ii), we get

$\alpha = \tan\theta$ and $\beta = \frac{g}{2u^2\cos^2\theta}$

$\Rightarrow \alpha^2 = \frac{\sin^2\theta}{\cos^2\theta}$

$\therefore \frac{\beta}{\alpha^2} = \frac{g}{2u^2\cos^2\theta \times \frac{\sin^2\theta}{\cos^2\theta}} = \frac{g}{2u^2\sin^2\theta} \times \frac{2}{2}$

$\frac{4\beta}{\alpha^2} = \frac{2g}{u^2\sin^2\theta} = \frac{1}{H} \Rightarrow H = \alpha^2/4\beta$

$\theta = \tan^{-1}\alpha$ and $H = \alpha^2/4\beta$

Question134

The velocity of a particle is $v = v_0 + gt + F t^2$. Its position is x = 0 at t = 0, then its displacement after time (t = 1) is [17 Mar 2021 Shift 2]

Options:

A. $v_0 + g + F$

B. $v_0 + \frac{g}{2} + \frac{F}{3}$

C. $v_0 + \frac{g}{2} + F$

D. $v_0 + 2g + 3F$

Answer: B

Solution:

Solution:
Given, equation of velocity,
$v = v_0 + gt + F t^2$
At $t = 0, x = 0$
At $t = 1s x = ?$
We know that, $v = \frac{dx}{dt}$
$dx = v dt$
Integrating the above equation with proper limits, we get
$\int_0^x dx = \int_0^{t-1} v dt$
$x - 0 = \int_0^{t-1} (v_0 + gt + F t^2) dt$

$\Rightarrow x = \left[v_0 t + \frac{gt^2}{2} + \frac{F t^3}{3} \right]_0^1 \Rightarrow x = \left[v_0(1) + \frac{g(1)^2}{2} + \frac{F(1)^3}{3} \right] - 0$

$\Rightarrow x = \left[v_0 + \frac{g}{2} + \frac{F}{3} \right]$

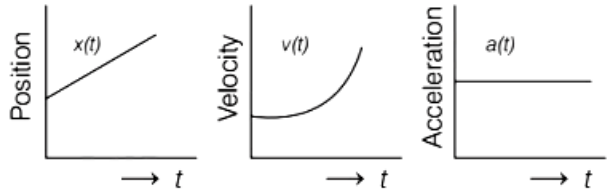
Question135

The position, velocity and acceleration of a particle moving with a constant acceleration can be represented by

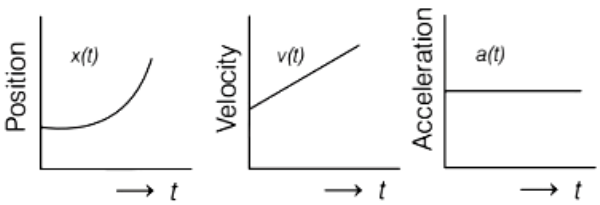
[18 Mar 2021 Shift 1]

Options:

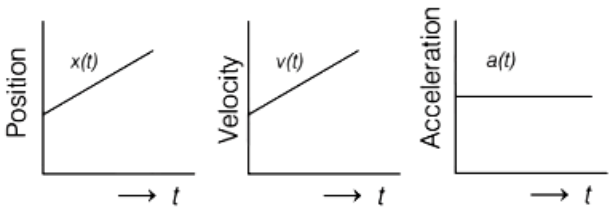
A.



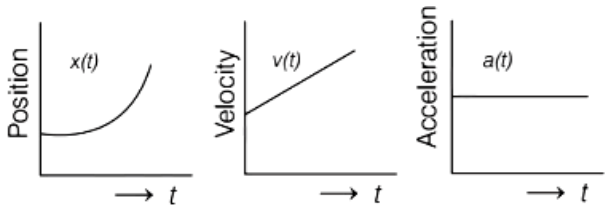
B.



C.



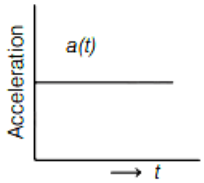
D.



Answer: B

Solution:

Solution:
Since, the particle is moving with constant acceleration. Acceleration = Constant, (the acceleration-time graph is parallel to the time axis, and acceleration is positive)



$a = \frac{dv}{dt}$

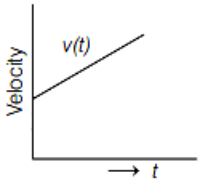
As we know,

$\frac{dv}{dt} = C \Rightarrow \int dv = C\int dt$

$\Rightarrow \quad v = Ct + C_0$

The velocity-time graph is straight line with positive slope

$V = \frac{dx}{dt}$

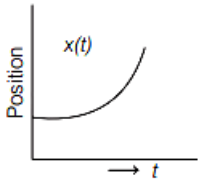


As we know,

$$\frac{dx}{dt} = Ct + C_0$$

$$\Rightarrow \int dx = \int (Ct + C_0)dt \Rightarrow x = \frac{Ct^2}{2} + C_0 t + C_1$$

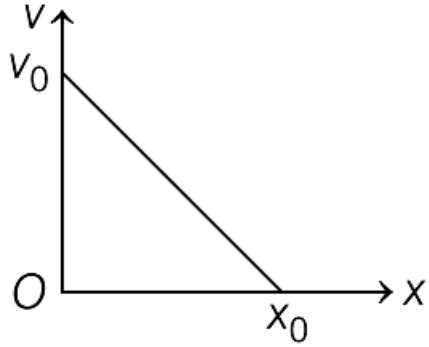
This equation shows that the distance-time graph is upward concave parabola.



Hence, the correct option is (b).

Question136

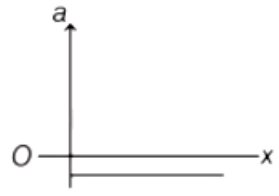
The velocity-displacement graph of a particle is shown in the figure.



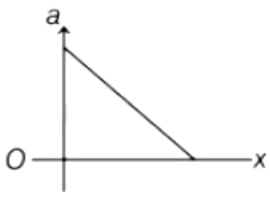
The acceleration-displacement graph of the same particle is represented by [18 Mar 2021 Shift 2]

Options:

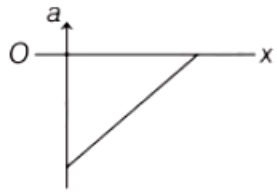
A.



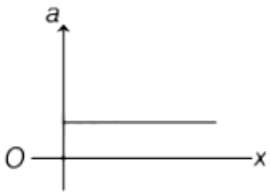
B.



C.



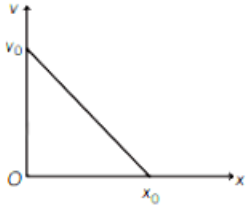
D.



Answer: C

Solution:

Solution:
For the given velocity-displacement graph,



Intercept, $c = v_0$

Slope, $m = -\frac{v_0}{x_0}$

$\therefore$ Slope, $m = \frac{dv}{dx} = -\frac{v_0}{x_0}$....(i)

For given diagram, the equation of line,

$y = mx + c$

$v = -\frac{v_0}{x_0}x + v_0$ ...(ii)

Acceleration, $a = \frac{dv}{dx} \times \frac{dx}{dt}$

$a = v\frac{dv}{dx}$

$a = \left(-\frac{v_0}{x_0}x + v_0\right)\left(-\frac{v_0}{x_0}\right)$ [From Eqs. (i) and (ii)]

$\Rightarrow \quad a = \left(\frac{v_0}{x_0}\right)^2 x - \frac{v_0^2}{x_0}$

Hence, the intercept is negative and the slope is positive, so the correct graph is given in option (c).

Question137

A car accelerates from rest at a constant rate α for some time after which it decelerates at a constant rate β to come to rest. If the total time elapsed is t seconds, the total distance travelled is
[17 Mar 2021 Shift 1]

Options:

A. $\frac{4\alpha\beta}{(\alpha+\beta)}t^2$

B. $\frac{2\alpha\beta}{(\alpha+\beta)}t^2$

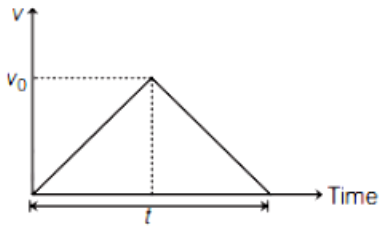
C. $\frac{\alpha\beta}{2(\alpha+\beta)}t^2$

D. $\frac{\alpha\beta}{4(\alpha+\beta)}t^2$

Answer: C

Solution:

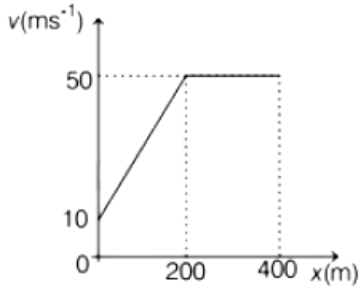
Solution:
Consider 1st case,
A car starts from rest at a constant acceleration α. It means
Acceleration, $a_1 = \alpha$
initial velocity, $u = 0$
$v = u + a_1 t \Rightarrow v_0 = 0 + \alpha t_1$
$\Rightarrow \ v_0 = \alpha t_1 ...(i)$
Consider 2nd case,
The same car decelerates after some time at a constant acceleration β and comes to rest. It means
Acceleration, $a_2 = \beta$
Final velocity $= 0$
$\Rightarrow \ v_0 = \beta t_2 ...(ii)$
According to question,
$t_1 + t_2 = t$
$\Rightarrow \ v_0\left(\frac{1}{\alpha} + \frac{1}{\beta}\right) = t$ [from Eqs. (i) & (ii)]
$\Rightarrow \ v_0 = \frac{\alpha\beta t}{\alpha+\beta} ...(iii)$
If we draw the velocity-time graph for the given situation, it will be as follows



∴ Distance travelled = Area of $v - t$ graph
$= \frac{1}{2} \times t \times v_0 = \frac{1}{2} \times t \times \frac{\alpha\beta t}{(\alpha+\beta)}$ [from Eq. (iii)]
$= \frac{1}{2}\frac{\alpha\beta t^2}{(\alpha+\beta)} = \frac{\alpha\beta t^2}{2(\alpha+\beta)}$

Question138

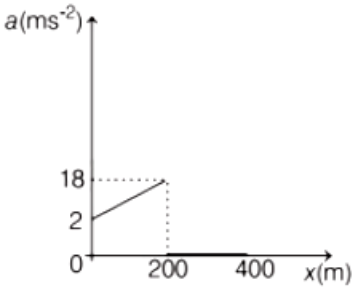
The velocity-displacement graph describing the motion of a bicycle is shown in the following figure.



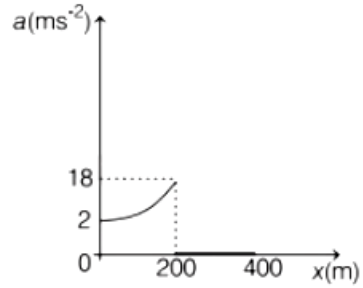
The acceleration-displacement graph of the bicycle's motion is best described by [16 Mar 2021 Shift 1]

Options:

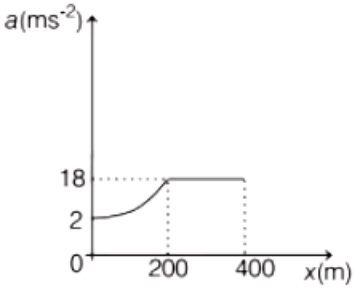
A.



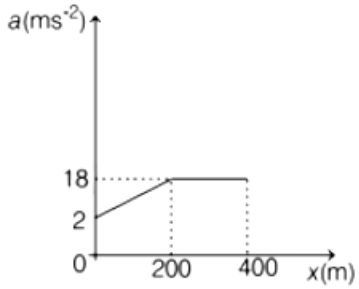
B.



C.



D.



Answer: A

Solution:

Solution:
From the given velocity-displacement graph, for $0 \le x \le 200$, the graph is a straight line i.e., varying linearly.
As, the equation of straight line is
$y = mx + c$
Here, it can be given as
$v = mx + c$
where, $m =$ slope $= \frac{(50-10)}{200-0} = \frac{1}{5}$ and $c = 10$

$\Rightarrow v = \frac{x}{5} + 10$

As, acceleration, $a = \frac{dv}{dt} = \frac{vdv}{dx}$

$a = \left(\frac{x}{5} + 10\right)\frac{d}{dx}\left(\frac{x}{5} + 10\right)$ [using Eq. (i)]

$= \left(\frac{x}{5} + 10\right)\left(\frac{1}{5}\right) = 2 + \frac{x}{25}$

For $x = 0$, $a = 2 + \frac{0}{25} = 2ms^{-2}$

and for $x = 200$, $a = 2 + \frac{200}{25} = 10ms^{-2}$

Therefore, the graph will have straight line till $x = 200$ and for $x > 200$; $v =$ constant and $a = 0$
So, from the graphs given in the options, the above conditions are satisfied in option (a) only.

Question139

The projectile motion of a particle of mass 5g is shown in the figure.

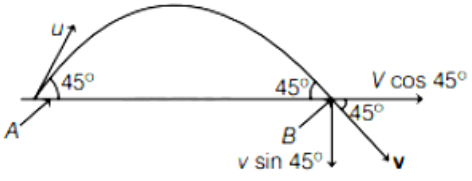
The initial velocity of the particle is $5\sqrt{2}ms^{-1}$ and the air resistance is assumed to be negligible. The magnitude of the change in momentum between the points A and B is $x \times 10^{-2}kg - ms^{-1}$. The value of x to the nearest integer, is
[18 Mar 2021 Shift 2]

Answer: 5

Solution:

Solution:

The given situation is shown below



Initial velocity of the projectile,
$u = u\cos 45^\circ \hat{i} + u\sin 45^\circ \hat{j}$
Final velocity of the projectile,
$v = v\cos 45^\circ \hat{i} - v\sin 45^\circ \hat{j}$
At point B, $v\cos 45^\circ = u\cos 45^\circ$
and $v\sin 45^\circ = u\sin 45^\circ$
$v = u\cos 45^\circ \hat{i} - u\sin 45^\circ \hat{j}$
The magnitude of change in the momentum between the points A and B
$|\Delta p| = |m(v-u)|$
$\Rightarrow \quad \Delta p = 2mu\sin 45^\circ$
$\Rightarrow \quad \Delta p = 2 \times 0.005 \times 5\sqrt{2} \times \frac{1}{\sqrt{2}}$
$\Rightarrow \quad \Delta p = 5 \times 10^{-2} kg - m/s$
Hence, the value of the x is 5 .

Question140

A mosquito is moving with a velocity $v = \left(0.5t^2\hat{i} + 3t\hat{j} + 9\hat{k}\right)$ m/s and accelerating in uniform conditions. What will be the direction of mosquito after 2s? [16 Mar 2021 Shift 2]

Options:

A. $\tan^{-1}\left(\frac{2}{3}\right)$ from X -axis

B. $\tan^{-1}\left(\frac{2}{3}\right)$ from γ-axis

C. $\tan^{-1}\left(\frac{5}{2}\right)$ from Y -axis

D. $\tan^{-1}\left(\frac{5}{2}\right)$ from X -axis

E. None of the above

Answer: E

Solution:

Solution:
Given, velocity of mosquito,
$v = \left(0.5t^2\hat{i} + 3t\hat{j} + 9\hat{k}\right)$ m/s
At $t = 2s$, $v = 0.5(2)^2\hat{i} + 3(2)\hat{j} + 9\hat{k}$
$= 2\hat{i} + 6\hat{j} + 9\hat{k}$
∴ Angle along X -axis,
$\cos\alpha = \frac{2}{\sqrt{2^2+6^2+9^2}} = \frac{2}{\sqrt{121}} = \frac{2}{11}$
or $\alpha = \cos^{-1}\left(\frac{2}{11}\right)$
Similarly, angle along Y -axis, $\cos\beta = \frac{6}{11}$

$\Rightarrow \beta = \cos^{-1}\left(\frac{6}{11}\right)$

Angle along Z-axis, $\cos\gamma = \frac{9}{11}$

$\Rightarrow \gamma = \cos^{-1}\left(\frac{9}{11}\right)$

$\therefore$ Angle made by the direction of motion of mosquito will be

$\cos^{-1}\left(\frac{2}{11}\right)$ from X-axis $= \tan^{-1}\frac{\sqrt{117}}{2}$

$\cos^{-1}\left(\frac{6}{11}\right)$ from Y-axis $= \tan^{-1}\frac{\sqrt{85}}{2}$

$\cos^{-1}\left(\frac{9}{11}\right)$ from Z-axis $= \tan^{-1}\left(\frac{\sqrt{40}}{9}\right)$

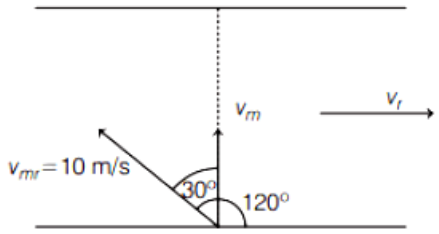
Question141

A person is swimming with a speed of 10m/s at an angle of 120° with the flow and reaches to a point directly opposite on the other side of the river. The speed of the flow is xm/s. The value of x to the nearest integer is .....
[18 Mar 2021 Shift 1]

Answer: 5

Solution:

Solution:
Given,
A person's swimming speed with respect to the river, $v_{mr} = 10\text{m/s}$
As shown in the figure,



Let's determine the speed of the river flow, v_r
In X-direction,
$v_r = v_{mr}\sin 30^\circ$
$v_r = 10 \times \sin 30^\circ$
$v_r = 5\text{m/s}$
Hence, the speed of the river flow is 5m/s. So, the value of the x to the nearest integer is 5 .

Question142

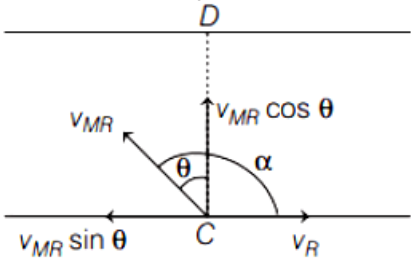
A swimmer can swim with velocity of 12km/h in still water. Water flowing in a river has velocity 6km/h. The direction with respect to the direction of flow of river water he should swim in order to reach the point on the other bank just opposite to his starting point is ..... (in degree).

(Round off to the nearest integer)
[16 Mar 2021 Shift 2]

Answer: 120

Solution:

Solution:
The situation is depicted in the following figure.



where, V_{MR} = velocity of man = 12km/h
and v_R = velocity of water flow in river = 6km/h
As, v_{MR} should be along CD.

$\Rightarrow v_R - v_{MR}\sin\theta = 0$

$\Rightarrow 6 - 12\sin\theta = 0 \Rightarrow \sin\theta = \frac{6}{12}$

$\Rightarrow \sin\theta = \frac{1}{2}$

$\Rightarrow \theta = \sin^{-1}\left(\frac{1}{2}\right) = \sin^{-1}(\sin 30^\circ) \quad \left[\because \sin 30^\circ = \frac{1}{2}\right]$

$\Rightarrow \theta = 30^\circ$

$\therefore \alpha = 90^\circ + \theta = 90^\circ + 30^\circ = 120^\circ$

$\Rightarrow \alpha = 120^\circ$

Question143

The instantaneous velocity of a particle moving in a straight line is given as $v = \alpha t + \beta t^2$, where alpha and beta are constants. The distance travelled by the particle between 1s and 2s is :
[25 Jul 2021 Shift 2]

Options:

A. $3\alpha + 7\beta$

B. $\frac{3}{2}\alpha + \frac{7}{3}\beta$

C. $\frac{\alpha}{2} + \frac{\beta}{3}$

D. $\frac{3}{2}\alpha + \frac{7}{2}\beta$

Answer: B

Solution:

Solution:

$V = \alpha t + \beta t^2$

$\frac{ds}{dt} = \alpha t + \beta t^2$

$\int_{S_1}^{s_2} ds = \int_1^2 (\alpha t + \beta t^2) dt$

$S_2 - S_1 = \left[\frac{\alpha t^2}{2} + \frac{\beta t^3}{3}\right]_1^2$

As particle is not changing direction

So distance = displacement.

Distance $= \left[\frac{\alpha[4-1]}{2} + \frac{\beta[8-1]}{3}\right]$

$= \frac{3}{2}\alpha + \frac{7}{2}\beta$

Question144

The relation between time t and distance x for a moving body is given as $t = mx^2 + nx$, where m and n are constants. The retardation of the motion is: (When v stands for velocity)
[25 Jul 2021 Shift 2]

Options:

A. $2mv^3$

B. $2mnv^3$

C. $2nv^3$

D. $2n^2v^3$

Answer: A

Solution:

Solution:

$t = mx^2 + nx$

$\frac{1}{v} = \frac{dt}{dx} = 2mx + n$

$v = \frac{1}{2mx + n}$

$\frac{dv}{dt} = -\frac{2m}{(2mx+n)^2}\left(\frac{dx}{dt}\right)$

$a = -(2m)v^3$

Question145

A boy reaches the airport and finds that the escalator is not working. He walks up the stationary escalator in time t_1. If he remains stationary on a moving escalator then the escalator takes him up in time t_2. The time taken by him to walk up on the moving escalator will be:
[20 Jul 2021 Shift 2]

Options:

A. $\frac{t_1 t_2}{t_2 - t_1}$

B. $\frac{t_1 + t_2}{2}$

C. $\frac{t_1 t_2}{t_2 + t_1}$

D. $t_2 - t_1$

Answer: C

Solution:

Solution:
L = Length of escalator
$V_{b/esc} = \frac{L}{t_1}$
When only escalator is moving.
$V_{esc} = \frac{L}{t_2}$
when both are moving
$V_{b/g} = V_{b/csc} + V_{csc}$
$V_{b/g} = \frac{L}{t_1} + \frac{L}{t_2} \Rightarrow \left[t = \frac{L}{V_{b/g}} = \frac{t_1 t_2}{t_1 + t_2} \right]$

Question146

A ball is thrown up with a certain velocity so that it reaches a height ' h '. Find the ratio of the two different times of the ball reaching $\frac{h}{3}$ in both the directions.

[27 Jul 2021 Shift 1]

Options:

A. $\frac{\sqrt{2} - 1}{\sqrt{2} + 1}$

B. $\frac{1}{3}$

C. $\frac{\sqrt{3} - \sqrt{2}}{\sqrt{3} + \sqrt{2}}$

D. $\frac{\sqrt{3} - 1}{\sqrt{3} + 1}$

Answer: C

Solution:

Solution:
$u = \sqrt{2gh}$
Now,
$S = \frac{h}{3} \quad a = -g$

$S = ut + \frac{1}{2}at^2$

$\frac{h}{3} = \sqrt{2gh}t + \frac{1}{2}(-g)t^2$

$t^2\left(\frac{g}{2}\right) - \sqrt{2gh}t + \frac{h}{3} = 0$

From quadratic equation

$t_1, t_2 = \frac{\sqrt{2gh} \pm \sqrt{2gh - \frac{4g}{2}\frac{h}{3}}}{g}$

$\frac{t_1}{t_2} = \frac{\sqrt{2gh} - \sqrt{\frac{4gh}{3}}}{\sqrt{2gh} + \sqrt{\frac{4gh}{3}}}$

$= \frac{\sqrt{3} - \sqrt{2}}{\sqrt{3} + \sqrt{2}}$

Question147

A balloon was moving upwards with a uniform velocity of 10 m/s. An object of finite mass is dropped from the balloon when it was at a height of 75 m from the ground level. The height of the balloon from the ground when object strikes the ground was around :

(takes the value of g as 10 m/s^2)

[25 Jul 2021 Shift 2]

Options:

A. 300 m

B. 200 m

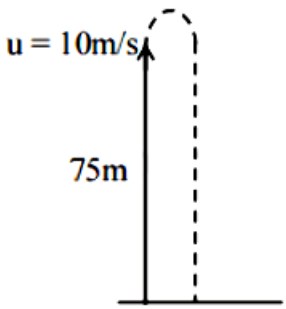
C. 125 m

D. 250 m

Answer: C

Solution:

Solution:



Object is projected as shown so as per motion under gravity

$S = ut + \frac{1}{2}at^2$

$-75 = +10t + \frac{1}{2}(-10)t^2 \Rightarrow t = 5\text{sec}$

Object takes $t = 5s$ to fall on ground

Height of balloon from ground

$H = 75 + ut$
$= 75 + 10 \times 5 = 125m$

Question148

Water droplets are coming from an open tap at a particular rate. The spacing between a droplet observed at 4^{th} second after its fall to the next droplet is 34.3m. At what rate the droplets are coming from the tap ? (Take $g = 9.8m/s^2$)
[25 Jul 2021 Shift 1]

Options:

A. 3 drops / 2 seconds

B. 2 drops / second

C. 1 drop / second

D. 1 drop / 7 seconds

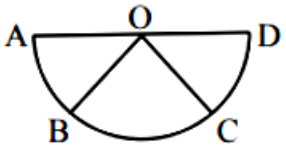
Answer: C

Solution:

Solution:
In 4 sec. 1^{st} drop will travel
$\Rightarrow \frac{1}{2} \times (9.8) \times (4)^2 = 78.4m$
$\therefore 2^{nd}$ drop would have travelled
$\Rightarrow 78.4 - 34.3 = 44.1m.$
Time for 2^{nd} drop
$\frac{1}{2}(9.8)t^2 = 44.1$
$t = 3sec$
$\therefore$ each drop have time gap of $1sec$
$\therefore 1$ drop per sec

Question149

Assertion A: If A, B, C, D are four points on a semi-circular arc with centre at 'O' such that $\left|\vec{AB}\right| = \left|\vec{BC}\right| = \left|\vec{CD}\right|$, then $\vec{AB} + \vec{AC} + \vec{AD} = 4\vec{AO} + \vec{OB} + \vec{OC}$
Reason R : Polygon law of vector addition yields $\vec{AB} + \vec{BC} + \vec{CD} + \vec{AD} = 2\vec{AO}$



In the light of the above statements, choose the most appropriate answer from the options given below :
[27 Jul 2021 Shift 1]

Options:

A. A is correct but R is not correct.

B. A is not correct but R is correct.

C. Both A and R are correct and R is the correct explanation of A.

D. Both A and R are correct but R is not the correct explanation of A.

Answer: D

Solution:

Solution:
Polygon law is applicable in both but the equation given in the reason is not useful in explaining the assertion.

Question150

Two vectors $\vec{X}$ and $\vec{Y}$ have equal magnitude. The magnitude of $\left(\vec{X}-\vec{Y}\right)$ is n times the magnitude of $\left(\vec{X}+\vec{Y}\right)$. The angle between$\vec{X}$ and $\vec{Y}$ is : [25 Jul 2021 Shift 2]

Options:

A. $\cos^{-1}\left(\frac{-n^2-1}{n^2-1}\right)$

B. $\cos^{-1}\left(\frac{n^2-1}{-n^2-1}\right)$

C. $\cos^{-1}\left(\frac{n^2+1}{-n^2-1}\right)$

D. $\cos^{-1}\left(\frac{n^2+1}{n^2-1}\right)$

Answer: B

Solution:

Solution:
Given $X = Y$

$$\sqrt{X^2+Y^2-2\times Y\cos\theta} = n\sqrt{X^2+Y^2+2\times Y\cos\theta}$$

Square both sides

$$2X^2(1-\cos\theta) = n^2 . 2X^2(1+\cos\theta)$$

$$1-\cos\theta = n^2+n^2\cos\theta$$

$$\cos\theta = \frac{1-n^2}{1+n^2}$$

$$\theta = \cos^{-1}\left[\frac{n^2-1}{-n^2-1}\right]$$

Question151

Match List I with List II.
Choose the correct answer from the options given below :
[25 Jul 2021 Shift 1]

Options:

A. (a) → (iv), (b) → (i) , (c) → (iii), (d) → (ii)

B. (a) → (iv), (b) → (iii) , (c) → (i), (d) → (ii)

C. (a) → (iii), (b) → (ii) , (c) → (iv), (d) → (i)

D. (a) → (i), (b) → (iv) , (c) → (ii), (d) → (iii)

Answer: B

Solution:

Solution:
(a) $\vec{C} = \vec{A} + \vec{B}$
Option (iv)
(b) $\vec{A} = \vec{B} + \vec{C} = \vec{C} + \vec{B}$
Option (iii)
(c) $\vec{B} = \vec{A} + \vec{C}$
Option (i)
(d) $\vec{A} + \vec{B} + \vec{C} = 0$
Option (ii)

Question152

What will be the projection of vector $\vec{A} = \hat{i} + \hat{j} + \hat{k}$ on vector $\vec{B} = \hat{i} + \hat{j}$?
[22 Jul 2021 Shift 2]

Options:

A. $\sqrt{2}\left(\hat{i} + \hat{j} + \hat{k}\right)$

B. $2\left(\hat{i} + \hat{j} + \hat{k}\right)$

C. $\sqrt{2}\left(\hat{i} + \hat{j}\right)$

D. $\left(\hat{i} + \hat{j}\right)$

Answer: D

Solution:

Solution:

$(A\cos\theta)\hat{B} = A\left(\frac{\vec{A}\cdot\vec{B}}{AB}\right)\hat{B} = \frac{\vec{A}\cdot\vec{B}}{B}\hat{B}$

$= \frac{2}{\sqrt{2}}\left(\frac{\hat{i}+\hat{j}}{\sqrt{2}}\right) = \hat{i}+\hat{j}$

Question153

Two vectors $\vec{P}$ and $\vec{Q}$ have equal magnitudes. If the magnitude of $\vec{P}+\vec{Q}$ is n times the magnitude of $\vec{P}-\vec{Q}$, then angle between $\vec{P}$ and $\vec{Q}$ is :
[20 Jul 2021 Shift 2]

Options:

A. $\sin^{-1}\left(\frac{n-1}{n+1}\right)$

B. $\cos^{-1}\left(\frac{n-1}{n+1}\right)$

C. $\sin^{-1}\left(\frac{n^2-1}{n^2+1}\right)$

D. $\cos^{-1}\left(\frac{n^2-1}{n^2+1}\right)$

Answer: D

Solution:

Solution:
$|\vec{P}| = |\vec{Q}| = x$ .....(i)
$|\vec{P}+\vec{Q}| = n|\vec{P}-\vec{Q}|$
$P^2+Q^2+2PQ\cos\theta = n^2(P^2+Q^2-2PQ\cos\theta)$
Using (i) in above equation
$\cos\theta = \frac{n^2-1}{1+n^2}$
$\theta = \cos^{-1}\left(\frac{n^2-1}{n^2+1}\right)$

Question154

If $\vec{A}$ and $\vec{B}$ are two vectors satisfying the relation $\vec{A}\cdot\vec{B} = |\vec{A}\times\vec{B}|$. Then the value of $|\vec{A}-\vec{B}|$ will be
[20 Jul 2021 Shift 1]

Options:

A. $\sqrt{A^2+B^2}$

B. $\sqrt{A^2+B^2+\sqrt{2}AB}$

C. $\sqrt{A^2+B^2+2AB}$

D. $\sqrt{A^2+B^2-\sqrt{2}AB}$

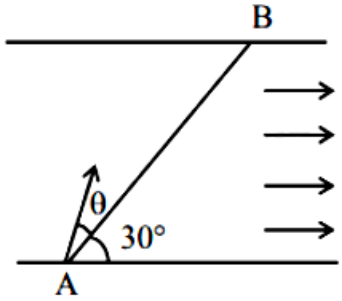
Answer: D

Solution:

Solution:
$\vec{A} \cdot \vec{B} = |\vec{A} \times \vec{B}|$
$AB\cos\theta = AB\sin\theta \Rightarrow \theta = 45°$
$|\vec{A} - \vec{B}| = \sqrt{A^2+B^2-2AB\cos 45°}$
$= \sqrt{A^2+B^2-\sqrt{2}AB}$
Hence option (4).

Question155

A swimmer wants to cross a river from point A to point B. Line AB makes an angle of 30° with the flow of river. Magnitude of velocity of the swimmer is same as that of the river. The angle θ with the line AB should be ____°, so that the swimmer reaches point B.

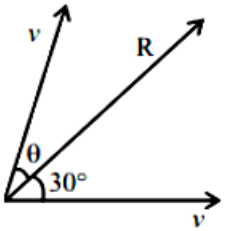


[27 Jul 2021 Shift 2]

Answer: 30

Solution:

Solution:



Both velocity vectors are of same magnitude therefore resultant would pass exactly midway through them
θ = 30°

Question156

Three particles P, Q and R are moving along thevectors $\vec{A} = \hat{i} + \hat{j}$, $\vec{B} = \hat{j} + \hat{k}$ and $\vec{C} = -\hat{i} + \hat{j}$respectively. They strike on a point and start tomove in different directions. Now particle P ismoving normal to the plane which contains vector$\vec{A}$ and $\vec{B}$. Similarly particle Q is moving normalto the plane which contains vector $\vec{A}$ and $\vec{C}$. Theangle between the direction of motion of P and Qis $\cos^{-1}\left(\frac{1}{\sqrt{x}}\right)$. Then the value of x is _____.

[22 Jul 2021 Shift 2]

Answer: 3

Solution:

Solution:

Direction of P $\hat{v}_1 = \pm\frac{\vec{A}\times\vec{B}}{|\vec{A}\times\vec{B}|} = \pm\frac{\hat{i}-\hat{j}+\hat{k}}{\sqrt{3}}$

Direction of Q $\hat{v}_2 = \pm\frac{\vec{A}\times\vec{C}}{|\vec{A}\times\vec{C}|} = \pm\frac{2\hat{k}}{2} = \pm\hat{k}$

Angle between $\text{hat}\, v_1$ and $\text{hat}\, v_2$

$\frac{\hat{v}_1\cdot\hat{v}_2}{|\hat{v}_1||\hat{v}_2|} = \frac{\pm 1/\sqrt{3}}{(1)(1)} = \pm\frac{1}{\sqrt{3}}$

$\Rightarrow x = 3$

Question157

A butterfly is flying with a velocity $4\sqrt{2}$m/s in North-East direction. Wind is slowly blowing at 1m/s from North to South. The resultant displacement of the butterfly in 3 seconds is :
[20 Jul 2021 Shift 1]

Options:

A. 3m

B. 20m

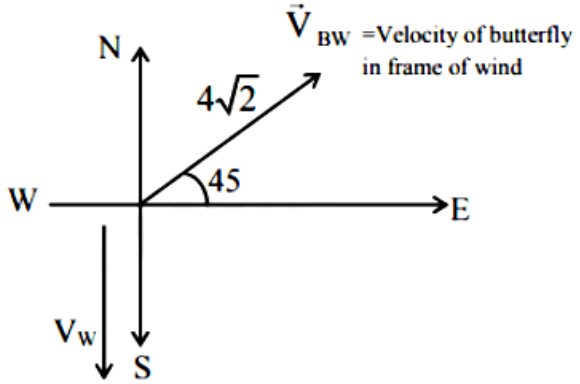
C. $12\sqrt{2}$m

D. 15m

Answer: D

Solution:

Solution:



$\vec{V}_{BW} = 4\sqrt{2}\cos 45\,\hat{i} + 4\sqrt{2}\sin 45\,\hat{j}$

$= 4\hat{i} + 4\hat{j}$

$\vec{V}_w = -\hat{j}$

$\vec{V}_B = \vec{V}_{BW} + \vec{V}_w = 4\hat{i} + 3\hat{j}$

$\vec{S}_B = \vec{V}_B \times t = \left(4\hat{i} + 3\hat{j}\right) \times 3 = 12\hat{i} + 9\hat{j}$

$\left|\vec{S}_B\right| = \sqrt{(12)^2 + (9)^2} = 15\text{m}$

Question158

If the velocity of a body related to displacement x is given by $v = \sqrt{5000 + 24x}$ m/s, then the acceleration of the body is ..... m/s^2.
[27 Aug 2021 Shift 1]

Answer: 12

Solution:

Solution:
Velocity of body is

$v = \sqrt{5000 + 24x}\,m/s$

Acceleration of body can be calculated as

$a = \frac{dv}{dt} = \frac{dv}{dx} \times \frac{dx}{dt}$

$\Rightarrow a = v\frac{dv}{dx}$ ...(i)

$\frac{dv}{dx} = \frac{d}{dx}(\sqrt{5000 + 24x})$

$\Rightarrow \frac{dv}{dx} = \frac{1}{2(\sqrt{5000 + 24x})} \times 24$

$= \frac{12}{\sqrt{5000 + 24x}}$

Substituting the value of $\frac{dv}{dx}$ in Eq. (i), we get

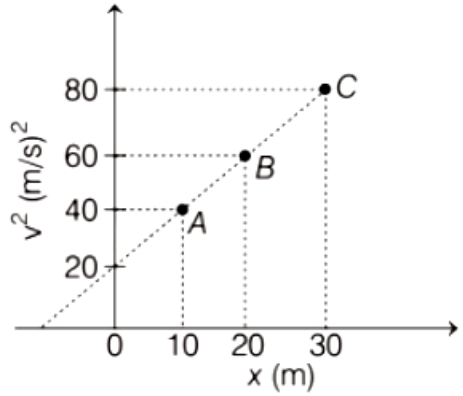
$a = \sqrt{5000 + 24x} \times \frac{12}{\sqrt{5000 + 24x}}$

$= 12\,m/s^2$

Thus, the acceleration of body is $12\,m/s^2$.

Question159

A particle is moving with constant acceleration a. Following graph shows v^2 versus x (displacement) plot. The acceleration of the particle is ..... m/s^2

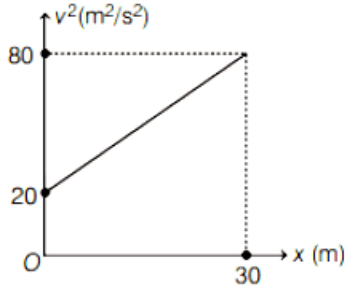


[31 Aug 2021 Shift 2]

Answer: 1

Solution:

Solution:
Av^2 versus x graph is shown below.



Using equation of motion,
$v^2 = u^2 + 2ax$ ...(i)
We know that, the equation of straight line.
y = mx + c ...(ii)
Comparing Eqs. (i) and (ii),
Slope, $m = 2a = \frac{80-20}{30-0} = \frac{60}{30} = 2$
Now, the acceleration, $a = \frac{2}{2} = 1 m/s^2$

Question160

Water drops are falling from a nozzle of a shower onto the floor, from a height of 9.8m. The drops fall at a regular interval of time. When the first drop strikes the floor, at that instant, the third drop begins to fall. Locate the position of second drop from the floor when the first drop strikes the floor.
[27 Aug 2021 Shift 2]

Options:

A. 4.18 m

B. 2.94 m

C. 2.45 m

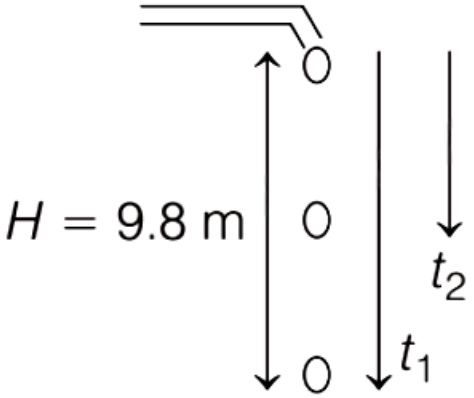
D. 7.35 m

Answer: D

Solution:

Solution:
Given, height of nozzle from floor,
$H = 9.8\text{m}$
Let, $t_1 =$ time taken by first drop to reach the ground
and $t_2 =$ time taken by 2 nd drop.

$t_2 = \frac{t_1}{2}$



$g =$ acceleration due to gravity (9.8ms^{-2})
$u =$ initial speed $= 0$
Since, $H = ut + \frac{1}{2}gt_1^2 \quad \cdots\cdots (i)$

$\therefore \; t_1 = \sqrt{\frac{2H}{g}}$

$\Rightarrow \; t_1 = \sqrt{\frac{2 \times 9.8}{9.8}} = \sqrt{2}\text{s}$

$\therefore \; t_2 = \frac{\sqrt{2}}{2} = \frac{1}{\sqrt{2}}\text{s}$

Again from Eq. (i)
Distance covered by 2 nd drop, $x = \frac{1}{2}gt_2^2$

$\therefore \; x = \frac{1}{2} \times 9.8 \times \left(\frac{1}{\sqrt{2}}\right)^2$

$= \frac{1}{2} \times 9.8 \times \frac{1}{2} = \frac{9.8}{4} = 2.45\text{m}$

and position of second drop from ground,
$H_2 = H_1 - x = 9.8 - 2.45 = 7.35\text{m}$

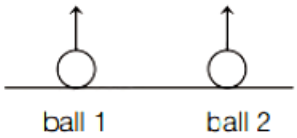
Question161

Two spherical balls having equal masses with radius of 5 cm each are thrown upwards along the same vertical direction at an interval of 3s with the same initial velocity of 35m/s, then these balls collide at a height of .....m. (Take, g = 10m/s^2)
[26 Aug 2021 Shift 1]

Answer: 50

Solution:

Solution:
Given, $m_1 = m_2 = m$
$r_1 = r_2 = r = 5\,cm = 5 \times 10^{-2} m$
$u_1 = u_2 = 35 m/s$
$t_1 = 0$
and $t_2 = 3s$



When both ball will collide,
$(S_1)_{vertical} = (S_2)_{vertical}$
Let after time t both ball will collide.
$(S_1)_{vertical} = u_1 t - \frac{1}{2}gt^2$
$(S_2)_{vertical} = u_2(t-3) - \frac{1}{2}g(t-3)^2$
From Eq. (i), we have
$\Rightarrow u_1 t - \frac{1}{2}gt^2 = u_2(t-3) - \frac{1}{2}g(t-3)^2$
$\Rightarrow 35t - \frac{1}{2} \times 10 \times t^2 = 35(t-3) - \frac{1}{2} \times 10(t-3)^2$
$\Rightarrow 35t - 35(t-3) = 5t^2 - 5(t-3)^2$
$\Rightarrow 35(t - t + 3) = 5[t^2 - (t-3)^2]$
$35 \times 3 = 5(t + t - 3)(t - t + 3)$
$\Rightarrow \frac{105}{5} = (2t-3)(3)$
$\Rightarrow \frac{21}{3} = 2t - 3$
$\Rightarrow 7 = 2t - 3$
$\Rightarrow 2t = 10$
$\Rightarrow t = 5s$
So, the height at which ball will collide is
$(S_1)_{vertical} = u_1 t - \frac{1}{2}gt^2$
$= 35 \times 5 - \frac{1}{2} \times 10 \times (5)^2$
$= 175 - 125$
$= 50m$

Question162

Statement I Two forces $(P + Q)$ and $(P - Q)$ where $P \perp Q$, when act at an angle θ_1 to each other, the magnitude of their resultant is $\sqrt{3(P^2 + Q^2)}$, when they act at an angle θ_2, the magnitude of their resultant becomes $\sqrt{2(P^2 + Q^2)}$. This is possible only when $\theta_1 < \theta_2$.
Statement II In the situation given above. $\theta_1 = 60°$ and $\theta_2 = 90°$.
In the light of the above statements, choose the most appropriate answer from the

options given below.
[31 Aug 2021 Shift 2]

Options:

A. Statement I is false but statement II is true.

B. Both statement I and statement II are true.

C. Statement I is true but statement II is false.

D. Both statement I and statement II are false.

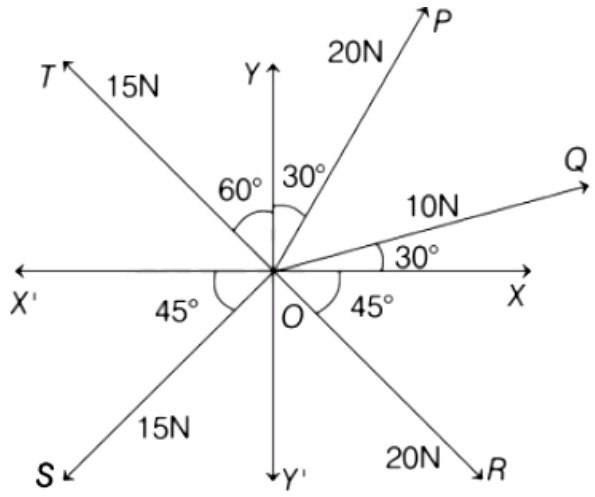
Answer: B

Solution:

Solution:
Given, force vectors $P \perp Q$, i.e. $\theta = 90°$
Let resultant of P + Q = x
and resultant of P − Q = y
$\therefore x^2 = P^2 + Q^2 + 2PQ\cos 90° = P^2 + Q^2$ ...(i)
$y^2 = P^2 + Q^2 - 2PQ\cos 90° = P^2 + Q^2$ ...(ii)
When θ_1 is the angle between (P + Q) and (P − Q),
then, their resultant is given by
$|x + y| = \sqrt{3(P^2 + Q^2)}$
$\therefore \sqrt{x^2 + y^2 + 2xy\cos\theta_1} = \sqrt{3P^2 + 3Q^2}$ ...(iii)
Substituting the values of x^2 and y^2 in Eq. (iii), we get
$P^2 + Q^2 + P^2 + Q^2 + 2\sqrt{P^2 + Q^2}\sqrt{P^2 + Q^2}\cos\theta_1 = 3P^2 + 3Q^2$
$2P^2 + 2Q^2 + (2P^2 + 2Q^2)\cos\theta_1 = 3P^2 + 3Q^2$
$\Rightarrow \cos\theta_1 = \frac{P^2 + Q^2}{2(P^2 + Q^2)} = \frac{1}{2}$
$\therefore \theta_1 = 60°$
When θ_2 is the angle between (P + Q) and (P − Q), then the magnitude of their resultant is given by
$|x + y| = \sqrt{2(P^2 + Q^2)}$
$x^2 + y^2 + 2xy\cos\theta_2 = 2P^2 + 2Q^2$ ...(iv)
Substituting the values, we get
$P^2 + Q^2 + P^2 + Q^2 + 2(P^2 + Q^2)\cos\theta_2 = 2P^2 + 2Q^2$
$\cos\theta_2 = 0$
$\Rightarrow \theta_2 = 90°$
So, $\theta_1 = 60°$ and $\theta_2 = 90°$ and $\theta_1 < \theta_2$
Hence, both statement I and statement II are true.

Question163

The resultant of these forces OP, OQ, OR, OS and OT is approximately ..... N. [Take, $\sqrt{3} = 1.7$, $\sqrt{2} = 1.4$ and given $\hat{i}$ and $\hat{j}$ unit vectors along X, Y axis



[27 Aug 2021 Shift 1]

Options:

A. $9.25\hat{i} + 5\hat{j}$

B. $3\hat{i} + 15\hat{j}$

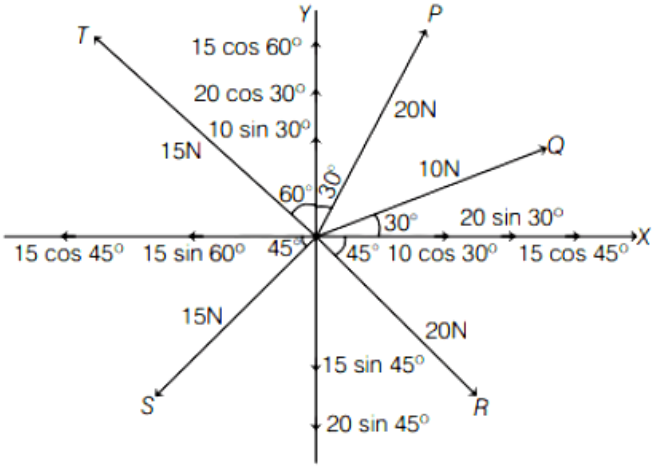
C. $2.5\hat{i} - 14.5\hat{j}$

D. $-1.5\hat{i} - 15.5\hat{j}$

Answer: A

Solution:

Solution:
From given figure, we can write all the forces in vector notation as



$\text{OP} = \left(20\sin 30°\,\hat{i} + 20\cos 30°\,\hat{j}\right)\text{N}$

$= \left(10\hat{i} + 17.32\hat{j}\right)\text{N}$

$\text{OQ} = \left(10\cos 30°\,\hat{i} + 10\sin 30°\,\hat{j}\right)\text{N}$

$= \left(8.66\hat{i} + 5\hat{j}\right)\text{N}$

$\text{OR} = \left(20\cos 45°\,\hat{i} - 20\sin 45°\,\hat{j}\right)\text{N}$

$= \left(14.14\hat{i} - 14.14\hat{j}\right)\text{N}$

$\text{OS} = \left(-15\cos 45°\,\hat{i} - 15\sin 45°\,\hat{j}\right)\text{N}$

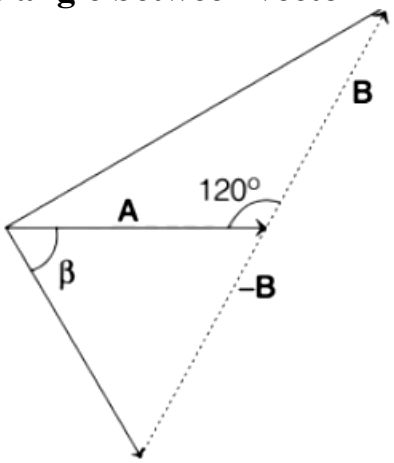
$= \left(-10.60\hat{i} - 10.60\hat{j}\right)\text{N}$

$\text{OT} = \left(-15\sin 60°\,\hat{i} + 15\cos 60°\,\hat{j}\right)\text{N}$

$= \left(-12.99\hat{i} + 7.5\hat{j}\right)N$
The resultant of these forces is given as
F = OP + OQ + OR + OS + OT
$F = \left[\left(10\hat{i} + 17.32\hat{j}\right) + \left(8.66\hat{i} + 5\hat{j}\right) + \left(14.14\hat{i} - 14.14\hat{i}\right) + \left(-10.60\hat{i} - 10.60\hat{j}\right) + \left(-12.99\hat{i} + 7.5\hat{j}\right)\right]$
$F = 9.21\hat{i} + 5.08\hat{j}N$
$F \approx 9.25\hat{i} + 5\hat{j}N$
Thus, the resultant force is
$F \approx 9.25\hat{i} + 5\hat{j}N$

Question164

The angle between vector A and (A - B) is



[26 Aug 2021 Shift 2]

Options:

A. $\tan^{-1}\left(\frac{-\frac{B}{2}}{A - B\frac{\sqrt{3}}{2}}\right)$

B. $\tan^{-1}\left(\frac{A}{0.7B}\right)$

C. $\tan^{-1}\left(\frac{\sqrt{3}B}{2A - B}\right)$

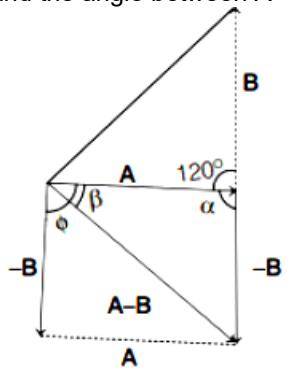
D. $\tan^{-1}\left(\frac{B\cos\theta}{A - B\sin\theta}\right)$

Answer: C

Solution:

Solution:
Given, angle between A and B, θ = 120°
The angle between A and – B, α = 180° − θ = 180° − 120° = 60°
Now, from diagram the resultant vector of A and −B will be A − B

and the angle between A − B and A is denoted by β.



So, angle between A and −B is calculated as,
ϕ = 180°− α = 180°− 60° = 120°
Now, from parallelogram law of vector addition angle β can becalculated as follows

$$\tan\beta = \frac{-B\sin\phi}{-A+(-B\cos\phi)}$$

$$= \frac{-B\sin 120°}{-A-B\cos 120°} = \frac{-B\frac{\sqrt{3}}{2}}{-A+\frac{B}{2}}$$

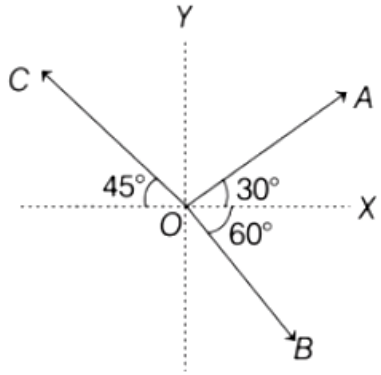
$$= \frac{\sqrt{3}B}{2A - B}$$

$$\beta = \tan^{-1}\left(\frac{\sqrt{3}B}{2A-B}\right)$$

Hence, the angle between vector A and (A - B) is $\tan^{-1}\left(\frac{\sqrt{3}B}{2A-B}\right)$.

Question165

The magnitude of vectors OA, OB, and OC in the given figure are equal. The direction of OA + OB - OC with X - axis will be



[26 Aug 2021 Shift 1]

Options:

A. $\tan^{-1}\frac{(1-\sqrt{3}-\sqrt{2})}{(1+\sqrt{3}+\sqrt{2})}$

B. $\tan^{-1}\frac{(\sqrt{3}-1+\sqrt{2})}{(1+\sqrt{3}-\sqrt{2})}$

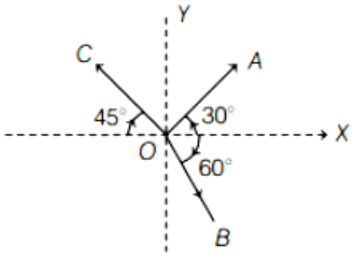
C. $\tan^{-1}\frac{(\sqrt{3}-1+\sqrt{2})}{(1-\sqrt{3}+\sqrt{2})}$

D. $\tan^{-1}\frac{(1+\sqrt{3}-\sqrt{2})}{(1-\sqrt{3}-\sqrt{2})}$

Answer: A

Solution:

Solution:
In the given figure, the magnitude of vectors OA, OB and OC are equal. Let it be m.
From figure, we can write



$$OA = m\left(\cos 30^\circ \hat{i} + \sin 30^\circ \hat{j}\right) = m\left(\frac{\sqrt{3}}{2}\hat{i} + \frac{1}{2}\hat{j}\right)$$

$$OB = m\left(\cos 60^\circ \hat{i} - \sin 60^\circ \hat{j}\right) = m\left(\frac{1}{2}\hat{i} - \frac{\sqrt{3}}{2}\hat{j}\right)$$

$$OC = m\left(\cos 45^\circ\left(-\hat{i}\right) + \sin 45^\circ \hat{j}\right) = m\left\{\frac{-1}{\sqrt{2}}\hat{i} + \frac{1}{\sqrt{2}}\hat{j}\right\}$$

According to the question, $OA + OB - OC = m\left(\frac{\sqrt{3}}{2}\hat{i} + \frac{1}{2}\hat{j}\right) + m\left(\frac{1}{2}\hat{i} - \frac{\sqrt{3}}{2}\hat{j}\right)$

$$-m\left(-\frac{1}{\sqrt{2}}\hat{i} + \frac{1}{\sqrt{2}}\hat{j}\right)$$

$$= m\hat{i}\left(\frac{\sqrt{3}}{2} + \frac{1}{2} + \frac{1}{\sqrt{2}}\right) + m\hat{j}\left(\frac{1}{2} - \frac{\sqrt{3}}{2} - \frac{1}{\sqrt{2}}\right)$$

∴ Angle with X - axis is given by

$$\tan\theta = \frac{y}{x} = \frac{m\left(\frac{1}{2} - \frac{\sqrt{3}}{2} - \frac{1}{\sqrt{2}}\right)}{m\left(\frac{\sqrt{3}}{2} + \frac{1}{2} + \frac{1}{\sqrt{2}}\right)}$$

$$\Rightarrow \tan\theta = \frac{\frac{1}{2} - \frac{\sqrt{3}}{2} - \frac{\sqrt{2}}{2}}{\frac{\sqrt{3}}{2} + \frac{1}{2} + \frac{\sqrt{2}}{2}}$$

$$\Rightarrow \tan\theta = \frac{1 - \sqrt{3} - \sqrt{2}}{\sqrt{3} + 1 + \sqrt{2}}$$

$$\Rightarrow \theta = \tan^{-1}\left(\frac{1 - \sqrt{3} - \sqrt{2}}{1 + \sqrt{3} + \sqrt{2}}\right)$$

Question166

A player kicks a football with an initial speed of $25ms^{-1}$ at an angle of 45° from the ground. What are the maximum height and the time taken by the football to reach at the highest point during motion ?
(Take, $g = 10ms^{-2}$)
[27 Aug 2021 Shift 2]

Options:

A. h_{max} = 10m, T = 2.5s

B. h_{max} = 15.625m, T = 3.54s

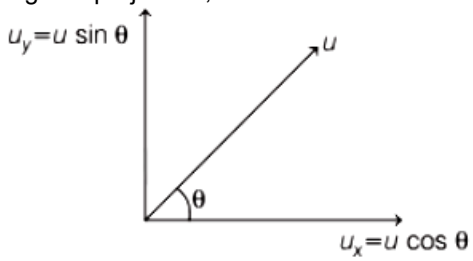
C. $h_{max} = 15.625m, T = 1.77s$

D. $h_{max} = 3.54m, T = 0.125s$

Answer: C

Solution:

Solution:
Given, initial speed, $u = 25ms^{-1}$
Angle of projection, $\theta = 45^{\circ}$



Let, the maximum height $= H$
Time taken to reach, $H = t$
Acceleration due to gravity $g = 10ms^{-2}$
Velocity at maximum height along Y -axis,
$v_y = 0ms^{-1}$
As we know that, for motion along
Y -axis,
$\because v_y^2 - u_y^2 = 2gH$
$\therefore 0^2 - (25\sin 45^{\circ})^2 = -2 \times 10 \times H$
$\Rightarrow -312.5 = -20H$
$\because H = 15.625m$
$\therefore H = \frac{1}{2}gt^2$
$\therefore = \sqrt{\frac{2H}{g}} = \sqrt{\frac{2 \times 15.625}{10}}$
$= 1.767 = 1.77s$

Question167

A helicopter is flying horizontally with a speed v at an altitude h has to drop a food packet for a man on the ground. What is the distance of helicopter from the man when the food packet is dropped?
[31 Aug 2021 Shift 1]

Options:

A. $\sqrt{\frac{2ghv^2 + 1}{h^2}}$

B. $\sqrt{2ghv^2 + h^2}$

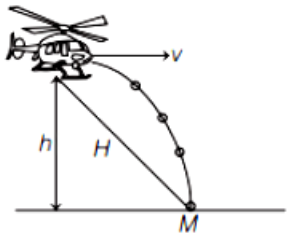
C. $\sqrt{\frac{2v^2h}{g} + h^2}$

D. $\sqrt{\frac{2gh}{v^2} + h^2}$

Answer: C

Solution:

Solution:
Given, horizontal velocity of helicopter, $u_x = v$
Height of the helicopter from ground = h
The given condition can be drawn in the figure given below



Here, M is the position of man.
Let, time taken by food packet to reach ground from helicopter = t
Acceleration due to gravity, $g = 10ms^{-2}$
Initial velocity of food packet along Y-axis, $u_y = 0$
Since, $h = u_y t + \frac{1}{2}gt^2$
$\therefore t = \sqrt{\frac{2h}{g}}$
and distance travelled by helicopter in time t along horizontal direction
$\Rightarrow x = u_x t$
$= v\sqrt{\frac{2h}{g}}$
Hence, distance of helicopter from man,
$H = \sqrt{h^2 + x^2} = \sqrt{h^2 + \left(v\sqrt{\frac{2h}{g}}\right)^2}$
$= \sqrt{h^2 + \frac{v^2 2h}{g}}$

Question168

A bomb is dropped by fighter plane flying horizontally. To an observer sitting in the plane, the trajectory of the bomb is a
[26 Aug 2021 Shift 2]

Options:

A. hyperbola

B. parabola in the direction of motion of plane

C. straight line vertically down the plane

D. parabola in a direction opposite to the motion of plane

Answer: C

Solution:

Solution:
The bomb is dropped from a fighter plane flying in horizontaldirection only.
Let us assume the velocity of fighter plane, $v_a = v_x\hat{i}$. As fighter plane is moving in horizontal direction only. Hence, it has only one component.

When fighter plane drops the bomb, the bomb will free fall from the fighter plane and have a horizontal velocity in the direction of plane and vertical velocity due to gravity.

Velocity of bomb can be given as, $v_b = v_x\hat{i} - v_y\hat{j}$. Velocity in vertical direction will be negative as bomb is moving downwards.

Now, for the person sitting inside the plane, hence the relative velocity of bomb with respect to plane can be calculated as

$v_{ba} = v_b - v_a = v_x\hat{i} - v_y\hat{j} - v_x\hat{i} = -v_y\hat{j}$

The velocity of bomb with respect to person sitting in plane is only in vertical direction. Thus, the trajectory of bomb with respect to the person will be a straight line vertically down to the plane.

Question169

A huge circular arc of length 4.4 ly subtends an angle 4s at the centre of the circle. How long it would take for a body to complete 4 rev if its speed is 8 AU per sec? [Given, 1 ly = 9.46×10^{15}m, 1 AU = 1.5×10^{11}m] [27 Aug 2021 Shift 1]

Options:

A. 4.1×10^8s

B. 4.5×10^{10}s

C. 3.5×10^6s

D. 7.2×10^8s

Answer: B

Solution:

Solution:

Length of arc, $I = 4.4\,\text{ly} = 4.4 \times 9.46 \times 10^{15}$

$= 4.1624 \times 10^{16}$m [$\because 1\,\text{Iy} = 9.46 \times 10^{15}$m]

Angle subtended by arc, θ = 4 s

Number of revolution, n = 4

Speed of body,

$v = 8\text{AUs}^{-1} = 1.5 \times 10^{11} \times 8 = 1.2 \times 10^{12}\text{ms}^{-1}$[$\because 1\,\text{AU} = 1.5 \times 10^{11}$m]

We know that, length of arc subtended by an angle,

$I = R\theta$

Here, R = radius of arc.

Substituting the values in above expression, we get

$4.1624 \times 10^{16} = R \times 4 \times \left(\frac{1^\circ}{3600}\right) \times \left(\frac{\pi}{180^\circ}\right)$ $\left(\because 1\text{s} = \frac{1}{3600}\,\text{degree}\right)$

$R = 2.146 \times 10^{21}$m

We know that, time = distance/speed

$t = \frac{n \times 2\pi R}{V}$

($\because$ Distance = n × length of circular path)

Substituting the values in above expression, we get

$t = \frac{4 \times 2\pi \times 2.146 \times 10^{21}}{1.2 \times 10^{12}}$

$= 4.5 \times 10^{10}$s

Thus, the time required is 4.5×10^{10}s.

Question170

The ranges and heights for two projectiles projected with the same initial velocity at angles 42° and 48° with the horizontal are R_1, R_2 and H_1, H_2, respectively. Choose the correct option.
[1 Sep 2021 Shift 2]

Options:

A. $R_1 > R_2$ and $H_1 = H_2$

B. $R_1 = R_2$ and $H_1 < H_2$

C. $R_1 < R_2$ and $H_1 < H_2$

D. $R_1 = R_2$ and $H_1 = H_2$

Answer: B

Solution:

Solution:
Here, two projectiles are projected at angles 42° and 48° withsame initial velocity.
As we know the expression of range of projectile,

Range $= \frac{u^2 \sin 2\theta}{g}$

At θ_1 = 42°

Range, $R_1 = \frac{u^2 \sin 2(42)°}{g} = \frac{0.99u^2}{g}$

At θ_2 = 48°

Range, $R_2 = \frac{u^2 \sin 2(48)°}{g} = \frac{0.99u^2}{g}$

The range of the projectile is same for the two projectiles.
Therefore, $R_1 = R_2$
Now, as we know the expression of height of the projectile,

$H_{max} = \frac{u^2 \sin\theta}{2g}$

At 42°,

$H_{max} = H_1 = \frac{u^2 \sin 42°}{2g} = \frac{0.669u^2}{2g}$

At 48°,

$H_{max} = H_2 = \frac{u^2 \sin 48°}{2g} = \frac{0.743u^2}{2g}$

Higher the value of q higher the value of maximum height.Therefore, $H_1 < H_2$.

Question171

A particle starts from the origin at t = 0 with an initial velocity of $3.0\hat{i}$ m/s and moves in the x − y plane with a constant acceleration $\left(6.0\hat{i} + 4.0\hat{j}\right)$ m/s^2. The x− coordinate of the particle at the instant when its y coordinate is 32m is D meters. The value of D is:
[9 Jan. 2020 II]

Options:

A. 32

B. 50

C. 60

D. 40

Answer: C

Solution:

Solution:
Using $S = ut + \frac{1}{2}at^2$

$y = u_y t + \frac{1}{2}a_y t^2$ (along y Axis)

$\Rightarrow 32 = 0 \times t + \frac{1}{2}(4)t^2$

$\Rightarrow \frac{1}{2} \times 4 \times t^2 = 32$

$\Rightarrow t = 4s$

$S_x = u_x t + \frac{1}{2}a_x t^2$ (Along x Axis)

$\Rightarrow x = 3 \times 4 + \frac{1}{2} \times 6 \times 4^2 = 60$

Question172

A particle is moving along the x -axis with its coordinate with time ' t ' given by $x(t) = 10 + 8t - 3t^2$. Another particle is moving along the y -axis with its coordinate as a function of time given by $y(t) = 5 - 8t^3$. At t = 1s, the speed of the second particle as measured in the frame of the first particle is given as $\sqrt{v}$. Then v(in m/s) is _____ [NA 8 Jan. 2020 I]

Answer: 580

Solution:

Solution:
For pariticle ' A '
$X_A = -3t^2 + 8t + 10$

$\vec{V}_A = (8 - 6t)\hat{i}$

$\vec{a}_A = -6\hat{i}$

For particle ' B '
$Y_B = 5 - 8t^3$

$\vec{V}_B = -24t^2\hat{j}$

$\vec{a}_B = -48\hat{t}$

At t = 1sec
$\vec{V}_A = (8 - 6t)\hat{i} = 2\hat{i}$ and $\vec{v}_B = -24\hat{j}$

$\therefore \vec{V}_{B/A} = -\vec{v}_A + \vec{v}_B = -2\hat{i} - 24\hat{j}$

$\therefore$ Speed of B w.r.t. A, $\sqrt{v} = \sqrt{2^2 + 24^2}$

$= \sqrt{4+576} = \sqrt{580}$
$\therefore v = 580(m/s)$

Question173

A particle moves such that its position vector $\vec{r}(t) = \cos \omega t \hat{i} + \sin \omega t \hat{j}$ where ω is a constant and t is time. Then which of the following statements is true for the velocity $\vec{v}$ (t) and acceleration $\vec{a}(t)$ of the particle:
[8 Jan. 2020 II]

Options:

A. $\vec{v}$ is perpendicular to $\vec{r}$ and $\vec{a}$ is directed away from the origin

B. $\vec{v}$ and $\vec{a}$ both are perpendicular to $\vec{r}$

C. $\vec{v}$ and $\vec{a}$ both are parallel to $\vec{r}$

D. $\vec{v}$ is perpendicular to $\vec{r}$ and $\vec{a}$ is directed towards the origin

Answer: D

Solution:

Solution:
Given, Position vector,
$\vec{r} = \cos \omega t \hat{i} + \sin \omega t \hat{j}$
Velocity, $\vec{v} = \frac{d\vec{r}}{dt} = \omega\left(-\sin \omega t \hat{i} + \cos \omega t \hat{j}\right)$
Acceleration,
$\vec{a} = \frac{d\vec{v}}{dt} = -\omega^2\left(\cos \omega t \hat{i} + \sin \omega t \hat{j}\right)$
$\vec{a} = -\omega^2 \vec{r}$
$\therefore \vec{a}$ is antiparallel to $\vec{r}$
Also $\vec{v} . \vec{r} = 0 \therefore \vec{v} \perp \vec{r}$
Thus, the particle is performing uniform circular motion.

Question174

A particle of mass m is projected with a speed u from the ground at an angle $\theta = \frac{\pi}{3}$ w.r.t. horizontal (x-axis). When it has reached its maximum height, it collides completely inelastically with another particle of the same mass and velocity $u\hat{i}$. The horizontal distance covered by the combined mass before reaching the ground is:
[9 Jan. 2020 II]

Options:

A. $\frac{3\sqrt{3}}{8}\frac{u^2}{g}$

B. $\frac{3\sqrt{2}}{4}\frac{u^2}{g}$

C. $\frac{5}{8}\frac{u^2}{g}$

D. $2\sqrt{2}\frac{u^2}{g}$

Answer: A

Solution:

Solution:
Apply momentum conservation
$\Rightarrow P_i = P_f$
$\Rightarrow mu + mu\cos\theta = 2mv$
$\Rightarrow V = \frac{u(1+\cos\theta)}{2}$

$= \frac{u(1+\cos 60^\circ)}{2} = \frac{u\left(1+\frac{1}{2}\right)}{2}$

$\Rightarrow v = \frac{3}{4}u \ldots\ldots\ldots\ldots (1)$

So, horizontal range after collision $= vt \ldots\ldots\ldots (2)$

Along vertical, $H_{max} = \frac{1}{2}gt^2 \Rightarrow t = \sqrt{\frac{2H_{max}}{g}}$ put in (2)

Horizontal range $= v \times \sqrt{\frac{2H_{max}}{g}}$

$= \frac{3}{4}u\sqrt{\frac{2u^2\sin^2 60}{2g^2}}\left(\because H_{max} = \frac{u^2\sin^2\theta}{2g}\right)$

$= \frac{3}{4}u^2\sqrt{\frac{2\times\left(\frac{\sqrt{3}}{2}\right)^2}{2g^2}}$

$= \frac{3}{4}u^2\frac{\sqrt{3/4}}{g}$

$= \frac{3\sqrt{3}u^2}{8g}$

Question175

The distance x covered by a particle in one dimensional motion varies with time t as $x^2 = at^2 + 2bt + c$. If the acceleration of the particle depends on x as x^{-n} , where n is an integer, the value of n is _____.
[NA 9 Jan 2020 I]

Answer: 3

Solution:

Solution:
Distance X varies with time t as $x^2 = at^2 + 2bt + c$
$\Rightarrow 2x\frac{dx}{dt} = 2at + 2b$
$\Rightarrow x\frac{dx}{dt} = at + b \Rightarrow \frac{dx}{dt} = \frac{(at+b)}{x}$

$\Rightarrow x\frac{d^2x}{dt^2}+\left(\frac{dx}{dt}\right)^2=a$

$\Rightarrow \frac{d^2x}{dt^2}=\frac{a-\left(\frac{dx}{dt}\right)^2}{x}=\frac{a-\left(\frac{at+b}{x}\right)^2}{x}$

$=\frac{ax^2-(at+b)^2}{x^3}=\frac{ac-b^2}{x^3}$

$\Rightarrow a \propto x^{-3}$

Hence, $n = 3$

Question176

A ball is dropped from the top of a 100 m high tower on a planet. In the last $\frac{1}{2}$s before hitting the ground, it covers a distance of 19 m. Acceleration due to gravity (in ms^{-2}) near the surface on that planet is _____.
[NA 8 Jan. 2020 II]

Answer: 8

Solution:

Solution:
Let the ball takes time t to reach the ground

Using, $S = ut+\frac{1}{2}gt^2$

$\Rightarrow S = 0\times t+\frac{1}{2}gt^2$

$\Rightarrow 200 = gt^2$ [$\because 2S = 100m$]

$\Rightarrow t = \sqrt{\frac{200}{g}}$ ...(i)

In last $\frac{1}{2}$ s, body travels a distance of 19 m, so in $\left(t-\frac{1}{2}\right)$ distance travelled = 81

Now, $\frac{1}{2}g\left(t-\frac{1}{2}\right)^2=81$

$\therefore g\left(t-\frac{1}{2}\right)^2=81\times 2$

$\Rightarrow \left(t-\frac{1}{2}\right)=\sqrt{\frac{81\times 2}{g}}$

$\therefore \frac{1}{2}=\frac{1}{\sqrt{g}}(\sqrt{200}-\sqrt{81\times 2})$ using (i)

$\Rightarrow \sqrt{g}=2(10\sqrt{2}-9\sqrt{2})$

$\Rightarrow \sqrt{g}=2\sqrt{2}$

$\therefore g = 8m/s^2$

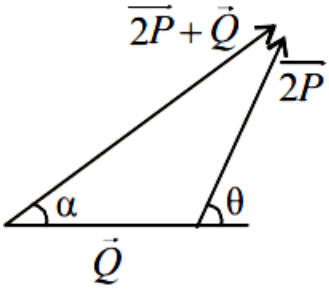
Question177

The sum of two forces $\vec{P}$ and $\vec{Q}$ is $\vec{R}$ such that $\left|\vec{R}\right| = \left|\vec{P}\right|$. The angle θ (in degrees) that the resultant of $2\vec{P}$ and $\vec{Q}$ will make with $\vec{Q}$ is _____.
[NA 7 Jan. 2020 II]

Answer: 90

Solution:

Solution:



$|\vec{R}| = |\vec{P}| \Rightarrow |\vec{P} + \vec{Q}| = |\vec{P}|$

$P^2 + Q^2 + 2PQ \cdot \cos\theta = P^2$

$\Rightarrow Q + 2P\cos\theta = 0$

$\Rightarrow \cos\theta = -\frac{Q}{2P}$

$\tan\alpha = \frac{2P\sin\theta}{Q + 2P\cos\theta} = \infty \ (\because 2P\cos\theta + Q = 0)$

$\Rightarrow \alpha = 90°$

Question178

Let $|\vec{A_1}| = 3, |\vec{A_2}| = 5$ and $|\vec{A_1} + \vec{A_2}| = 5$. The value of $\left(2\vec{A_1} + 3\vec{A_2}\right) \cdot \left(3\vec{A_1} - 2\vec{A_2}\right)$ is : [8 April 2020 II]

Options:

A. – 106.5

B. – 99.5

C. – 112.5

D. – 118.5

Answer: D

Solution:

Solution:
Using,

$R^2 = A_1^{\ 2} + A_2^{\ 2} + 2A_1A_2\cos\theta$

$5^2 = 3^2 + 5^2 + 2 \times 3 \times 5\cos\theta$

or $\cos\theta = -0.3$

$\left(2\vec{A_1} + 3\vec{A_2}\right) \cdot \left(3\vec{A_1} - 2\vec{A_2}\right) = 2A_1 \times 3A_1 + (3A_2)(3A_1)\cos\theta - (2A_1)(2A_2)\cos\theta - 3A_2 \times 2A_2$

$= 6A_1^{\ 2} + 9A_1A_2\cos\theta - 4A_1A_2\cos\theta - 6A_2^{\ 2}$

$= 6A_1^{\ 2}6A_2^{\ 2} + 5A_1^{\ -}A_2\cos\theta$

$= 6 \times 3^2 - 6 \times 5^2 + 5 \times 3 \times 5(-0.3)$

$= -118.5$

Question179

A clock has a continuously moving second's hand of 0.1 m length. The average acceleration of the tip of the hand (in units of ms^{-2}) is of the order of :
Sep. 06, 2020 (I)

Options:

A. 10^{-3}

B. 10^{-4}

C. 10^{-2}

D. 10^{-1}

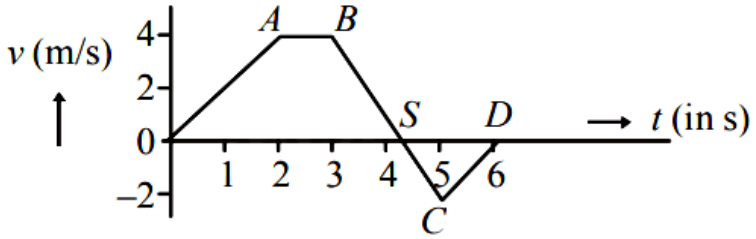
Answer: A

Solution:

Solution:
Here, $R = 0.1m$
$\omega = \frac{2\pi}{T} = \frac{2\pi}{60} = 0.105\,rad/s$
Acceleration of the tip of the clock second's hand,
$a = \omega^2 R = (0.105)^2(0.1) = 0.0011 = 1.1 \times 10^{-3} m/s^2$
Hence, average acceleration is of the order of 10^{-3}.

Question180

The velocity (v) and time (t) graph of a body in a straight line motion is shown in the figure. The point S is at 4.333 seconds. The total distance covered by the body in 6 s is:



[05 Sep. 2020 (II)]

Options:

A. $\frac{37}{3}$ m

B. 12 m

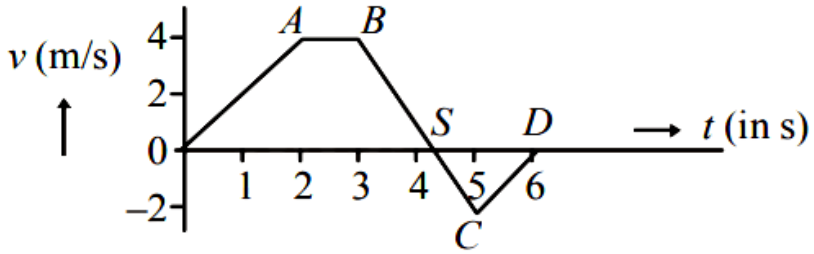
C. 11 m

D. $\frac{49}{4}$ m

Answer: A

Solution:

Solution:



$OS = 4 + \frac{1}{3} = \frac{13}{3}$

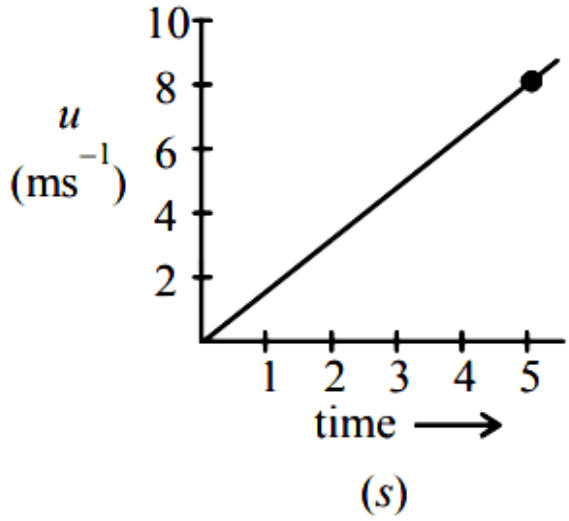
$SD = 2 - \frac{1}{3} = \frac{5}{3}$

Distance covered by the body = area of v-t graph = ar (OABS) + ar (SCD)

$= \frac{1}{2}(133 + 1) \times 4 + \frac{1}{2} \times \frac{5}{3} \times 2 \ = \frac{32}{3} + \frac{5}{3} = \frac{37}{3}\text{m}$

Question181

The speed verses time graph for a particle is shown in the figure. The distance travelled (in m) by the particle during the time interval t = 0 to t = 5 s will be _____.

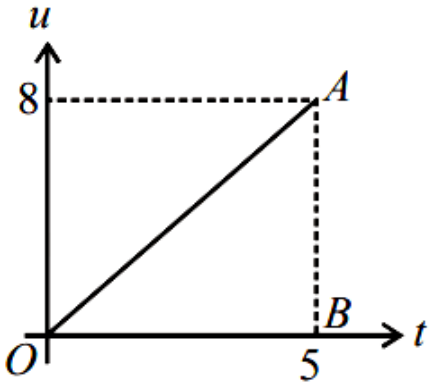


[NA 4 Sep. 2020 (II)]

Answer: 20

Solution:

Solution:



Distance travelled = Area of speed-time graph $= \frac{1}{2} \times 5 \times 8 = 20\text{m}$

Question182

Train A and train B are running on parallel tracks in the opposite directions with speeds of 36 km/hour and 72 km/hour, respectively. A person is walking in train A in the direction opposite to its motion with a speed of 1.8 km/hour. Speed (in ms^{-1}) of this person as observed from train B will be close to : (take the distance between the tracks as negligible)
[2 Sep. 2020 (I)]

Options:

A. 29.5 ms^{-1}

B. 28.5 ms^{-1}

C. 31.5 ms^{-1}

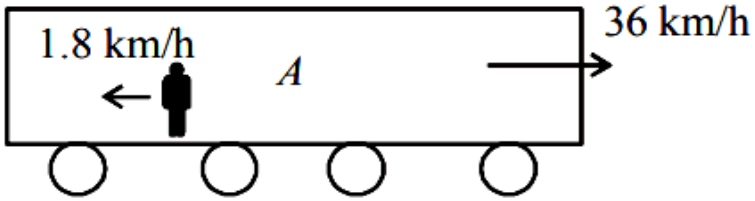
D. 30.5 ms^{-1}

Answer: A

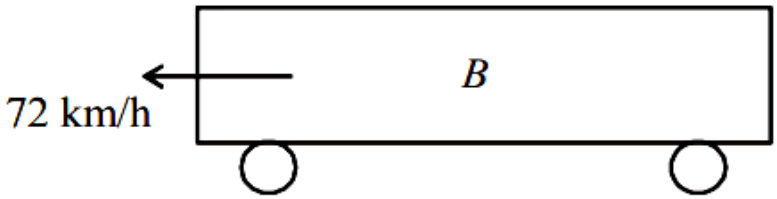
Solution:

Solution:

According to question, train A and B are running on parallel tracks in the opposite direction.



$V_A = 36 \text{ km/h} = 10 \text{ m/s}$



$V_B = -72\,km/h = -20m/s$
$V_{MA} = -1.8\,km/h = -0.5m/s$
$V_{man,B} = V_{man,A} + V_{A,B}$
$= V_{man,A} + V_A - V_B = -0.5 + 10 - (-20)$
$= -0.5 + 30 = 29.5m/s$

Question183

A helicopter rises from rest on the ground vertically upwards with a constant acceleration g. A food packet is dropped from the helicopter when it is at a height h. The time taken by the packet to reach the ground is close to [g is the acceleration due to gravity] :
[5 Sep. 2020 (I)]

Options:

A. $t = \frac{2}{3}\sqrt{\left(\frac{h}{g}\right)}$

B. $t = 1.8\sqrt{\left(\frac{h}{g}\right)}$

C. $t = 3.4\sqrt{\left(\frac{h}{g}\right)}$

D. $t = \sqrt{\left(\frac{2h}{3g}\right)}$

Answer: C

Solution:

Solution:
For upward motion of helicopter,
$v^2 = u^2 + 2gh \Rightarrow v^2 = 0 + 2gh \Rightarrow v = \sqrt{2gh}$
Now, packet will start moving under gravity.
Let 't' be the time taken by the food packet to reach the ground.

$s = ut + \frac{1}{2}at^2$

$\Rightarrow -h = \sqrt{2gh}t - \frac{1}{2}gt^2$

$\Rightarrow \frac{1}{2}gt^2 - \sqrt{2gh}t - h = 0$

or, $t = \frac{\sqrt{2gh} \pm \sqrt{2gh + 4 \times \frac{g}{2} \times h}}{2 \times \frac{g}{2}}$

or, $t = \sqrt{\frac{2gh}{g}}(1 + \sqrt{2})$

$\Rightarrow t = \sqrt{\frac{2h}{g}}(1 + \sqrt{2})$

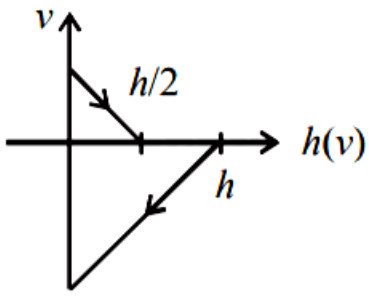
or, $t = 3.4\sqrt{\frac{h}{g}}$

Question184

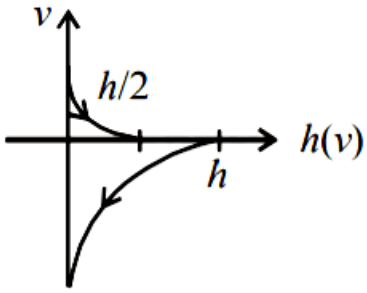
A Tennis ball is released from a height h and after freely falling on a wooden floor it rebounds and reaches height $\frac{h}{2}$. The velocity versus height of the ball during its motion may be represented graphically by:(graph are drawn schematically and on not to scale)
[4 Sep. 2020 (I)]

Options:

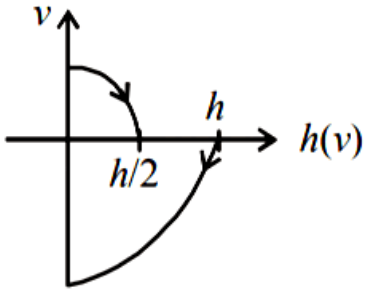
A.



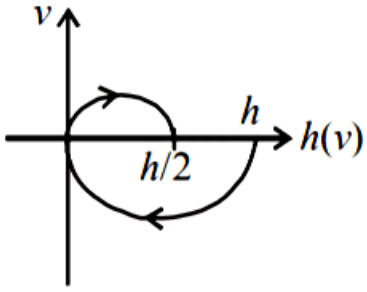
B.



C.



D.

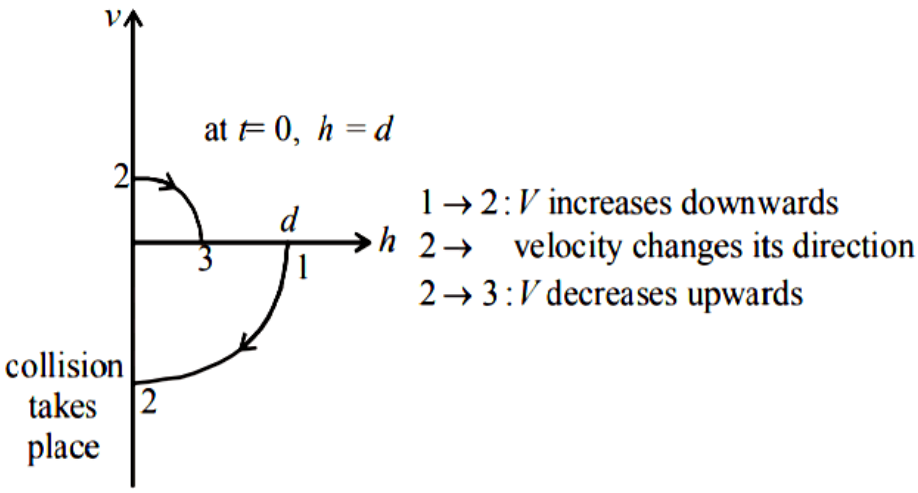


Answer: C

Solution:

Solution:
For uniformly accelerated/ deaccelerated motion :
$v^2 = u^2 \pm 2gh$

As equation is quadratic, so, $v - h$ graph will be a parabola



Initially velocity is downwards (–ve) and then after collision it reverses its direction with lesser magnitude, i.e. velocity is upwards (+ve).
Note that time t = 0 corresponds to the point on the graph
where h = d.
Next time collision takes place at 3.

Question185

A force $\vec{F} = \left(\hat{i} + 2\hat{j} + 3\hat{k}\right)$N acts at a point $\left(4\hat{i} + 3\hat{j} - \hat{k}\right)$m Then the magnitude of torque about the point $\left(\hat{i} + 2\hat{j} + \hat{k}\right)$m will be $\sqrt{x}$N-m. The value of x is _____.
[NA Sep. 05, 2020 (I)]

Answer: 13.96

Solution:

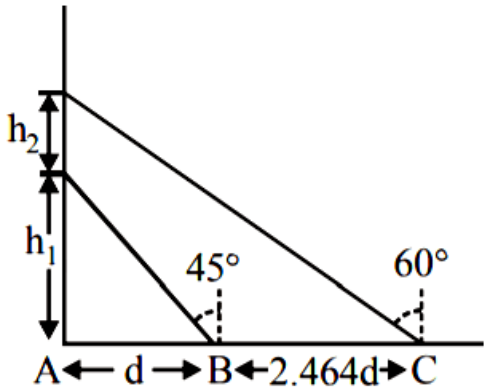
Solution:
Given : $\vec{F} = \left(\hat{i} + 2\hat{j} + 3\hat{k}\right)$N
And, $\vec{r} = \left[\left(4\hat{i} + 3\hat{j} - \hat{k}\right) - \left(\hat{i} + 2\hat{j} + \hat{k}\right)\right] = 3\hat{i} + \hat{j} - 2\hat{k}$
Torque, $\tau = \vec{r} \times \vec{F} = \left(3\hat{i} + \hat{j} - 2\hat{k}\right) \times \left(\hat{i} + 2\hat{j} + 3\hat{k}\right)$

$$\tau = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 3 & 1 & -2 \\ 1 & 2 & 3 \end{vmatrix} = 7\hat{i} - 11\hat{j} + 5\hat{k}$$

Magnitude of torque, $\left|\vec{\tau}\right| = \sqrt{195} = 13.96$

Question186

A balloon is moving up in air vertically above a point A on the ground. When it is at a height h_1, a girl standing at a distance d (point B) from A (see figure) sees it at an angle 45° with respect to the vertical. When the balloon climbs up a further height h_2, it is seen at an angle 60° with respect to the vertical if the girl moves further by a distance 2.464 d (point C). Then the height h_2 is (given tan 30° = 0.5774):



[Sep. 05, 2020 (I)]

Options:

A. 1.464 d

B. 0.732 d

C. 0.464 d

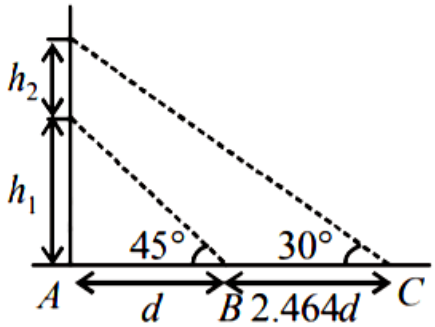
D. d

Answer: D

Solution:

Solution:
From figure/ trigonometry,

$\frac{h_1}{d} = \tan 45° \Rightarrow \therefore h_1 = d$



And, $\frac{h_1 + h_2}{d + 2.464d} = \tan 30°$

$\Rightarrow (h_1 + h_2) \times \sqrt{3} = 3.46d$

$\Rightarrow (h_1 + h_2) = \frac{3.46d}{\sqrt{3}}$

$\Rightarrow d + h_2 = \frac{3.46d}{\sqrt{3}}$

$\therefore h_2 = d$

Question187

Starting from the origin at time t = 0, with initial velocity $5\hat{j}ms^{-1}$, a particle moves in the x − y plane with a constant acceleration of $\left(10\hat{i}+4\hat{j}\right)ms^{-2}$. At time t, its co-ordiantesare (20m, y_0m). The values of t and y_0 are, respectively:
[Sep. 04, 2020 (I)]

Options:

A. 2 s and 18 m

B. 4 s and 52 m

C. 2 s and 24 m

D. 5 s and 25 m

Answer: A

Solution:

Solution:
Given : $\vec{u}=5\hat{j}m/s$
Acceleration, $\vec{a}=10\hat{i}+4\hat{j}$ and
final coordinate $(20, y_0)$ in time t.
$S_x = u_x t + \text{frac } 1\ 2\ a_x t^2$ [$\because u_x = 0$]
$\Rightarrow 20 = 0 + \frac{1}{2} \times 10 \times t^2 \Rightarrow t = 2s$
$S_y = u_y \times t + \frac{1}{2} a_y t^2$
$y_0 = 5 \times 2 + \frac{1}{2} \times 4 \times 2^2 = 18m$

Question188

When a carsit at rest, its driver sees raindrops falling on it vertically. When driving the car with speed v, he sees that raindrops are coming at an angle 60º from the horizontal. On furter increasing the speed of the car to (1 + β)v, this angle changes to 45º. The value of β is close to:
[Sep. 06, 2020 (II)]

Options:

A. 0.50

B. 0.41

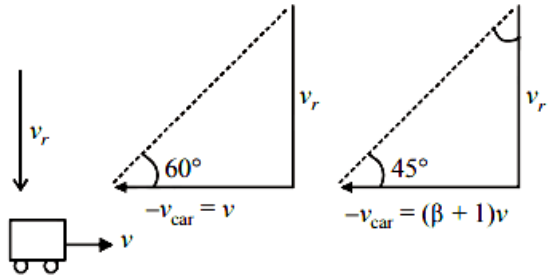
C. 0.37

D. 0.73

Answer: D

Solution:

Solution:
The given situation is shown in the diagram. Here v_r be the velocity of rain drop.



When car is moving with speed v

$\tan 60° = \frac{v_r}{v}$ .....(i)

When car is moving with speed $(1+\beta)v$,

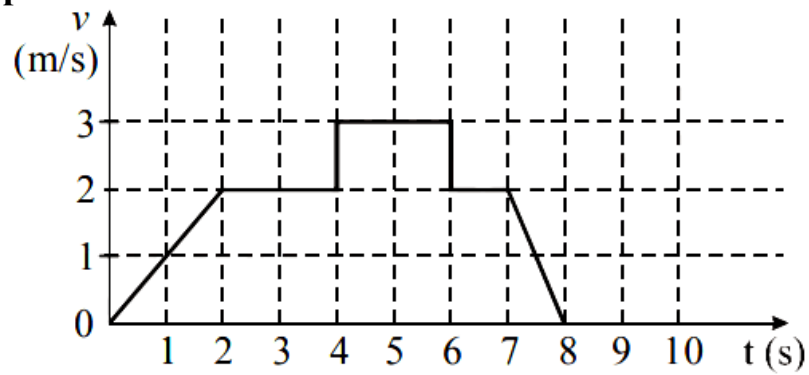
$\tan 45° = \frac{v_r}{(\beta+1)v}$ .....(ii)

Dividing (i) by (ii) we get,

$\sqrt{3}v = (\beta+1)v \Rightarrow \beta = \sqrt{3} - 1 = 0.732.$

Question189

A particle starts from the origin at time t = 0 and moves along the positive x-axis. The graph of velocity with respect to time is shown in figure. What is the position of the particle at time t = 5s?



[10 Jan. 2019 II]

Options:

A. 10 m

B. 6 m

C. 3 m

D. 9 m

Answer: D

Solution:

Solution:
Position of the particle,
S = area under graph (time t = 0 to 5s)

$= \frac{1}{2} \times 2 \times 2 + 2 \times 2 + 3 \times 1 = 9\text{m}$

Question190

In a car race on straight road, car A takes a time t less than car B at the finish and passes finishing point with a speed ' v ' more than of car B. Both the cars start from rest and travel with constant acceleration a_1 and a_2 respectively. Then 'v' is equal to: [9 Jan. 2019 II]

Options:

A. $\frac{2a_1a_2}{a_1+a_2}t$

B. $\sqrt{2a_1a_2}t$

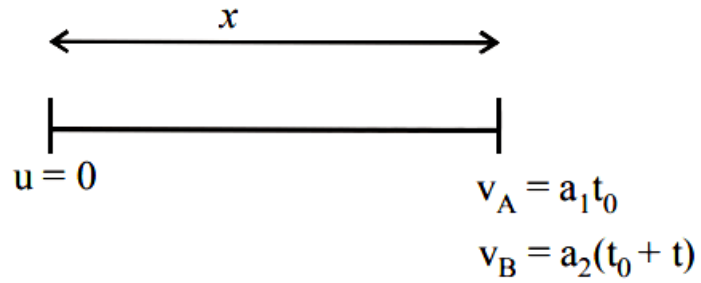
C. $\sqrt{a_1a_2}t$

D. $\frac{a_1+a_2}{2}t$

Answer: C

Solution:

Solution:
Let time taken by A to reach finishing point is t_0
$\therefore$ Time taken by B to reach finishing point $= t_0 + t$



$v_A - v_B = v$
$\Rightarrow v = a_1t_0 - a_2(t_0 + t) = (a_1 - a_2)t_0 - a_2t$....(i)
$x_B = x_A = \frac{1}{2}a_1t_0^2 = \frac{1}{2}a_2(t_0 + t)^2$
$\Rightarrow \sqrt{a_1}t = \sqrt{a_2}(t_0 + t)$
$\Rightarrow (\sqrt{a_1} - \sqrt{a_2})t_0 = \sqrt{a_2}t$
$\Rightarrow t_o = \frac{\sqrt{a_2}t}{\sqrt{a_1} - \sqrt{a_2}}$
Putting this value of t_0 in equation (i)
$v = (a_1 - a_2)\frac{\sqrt{a_2}t}{\sqrt{a_1} - \sqrt{a_2}} - a_2t$
$= (\sqrt{a_1} + \sqrt{a_2})\sqrt{a_2}t - a_2t = \sqrt{a_1a_2}t + a_2t - a_2t$
or, $v = \sqrt{a_1a_2}t$

Question191

A passenger train of length 60 m travels at a speed of 80 km/hr. Another freight train of length 120 m travels at a speed of 30 km/h. The ratio of times taken by the passenger train to completely cross the freight train when: (i) they are moving in same direction, and (ii) in the opposite directions is:
[12 Jan. 2019 II]

Options:

A. $\frac{11}{5}$

B. $\frac{5}{2}$

C. $\frac{3}{2}$

D. $\frac{25}{11}$

Answer: A

Solution:

Solution:

Question192

A person standing on an open ground hears the sound of a jet aeroplane, coming from north at an angle 60º with ground level. But he finds the aeroplane right vertically above his position. If v is the speed of sound, speed of the plane is:
[12 Jan. 2019 II]

Options:

A. $\frac{\sqrt{3}}{2}$v

B. $\frac{2v}{\sqrt{3}}$

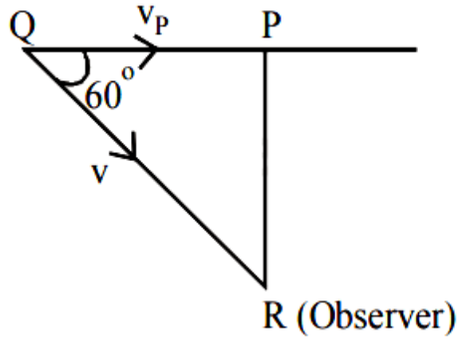
C. v

D. $\frac{v}{2}$

Answer: D

Solution:

Solution:



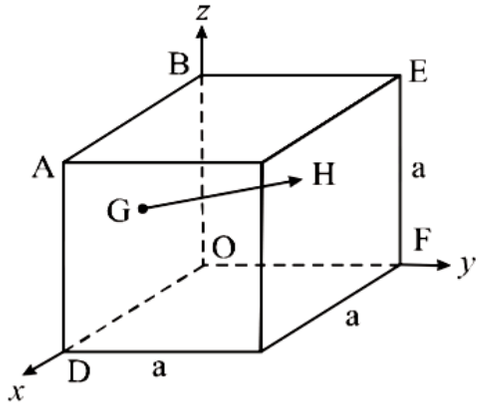
Distance, PQ = v_p × t (Distance = speed × time)
Distance, QR = V.t

$\cos 60° = \frac{PQ}{QR}$

$\frac{1}{2} = \frac{v_p \times t}{V.t} \Rightarrow v_p = \frac{v}{2}$

Question193

In the cube of side 'a' shown in the figure, the vector from the central point of the face ABOD to the central point of the face BEFO will be:



[10 Jan. 2019 I]

Options:

A. $\frac{1}{2}a\left(\hat{k}-\hat{i}\right)$

B. $\frac{1}{2}a\left(\hat{i}-\hat{k}\right)$

C. $\frac{1}{2}a\left(\hat{j}-\hat{i}\right)$

D. $\frac{1}{2}a\left(\hat{j}-\hat{k}\right)$

Answer: C

Solution:

Solution:
From Figure,
$\vec{r}_G = \frac{a}{2}\hat{i} + \frac{a}{2}\hat{k}$

$\vec{r}_H = \frac{a}{2}\hat{j} + \frac{a}{2}\hat{k}$

$\therefore \vec{r}_H - \vec{r}_G = \frac{a}{2}\left(\hat{j} - \hat{i}\right)$

Question194

Two forces P and Q, of magnitude 2F and 3F, respectively, are at an angle q with each other. If the force Q is doubled, then their resultant also gets doubled. Then, the angle q is:
[10 Jan. 2019 II]

Options:

A. 120°

B. 60°

C. 90°

D. 30°

Answer: A

Solution:

Solution:
Using, $R^2 = P^2 + Q^2 + 2PQ\cos\theta$
$4F^2 + 9F^2 + 12F^2\cos\theta = R^2$
When forces Q is doubled,
$4F^2 + 36F^2 + 24F^2\cos\theta = 4R^2$
$4F^2 + 36F^2 + 24F^2\cos\theta$
$= 4(13F^2 + 12F^2\cos\theta) = 52F^2 + 48F^2\cos\theta$
$\therefore \cos\theta = -\frac{12F^2}{24F^2} = -\frac{1}{2}$
$\Rightarrow \theta = 120°$

Question195

Two vectors $\vec{A}$ and $\vec{B}$ have equal magnitudes. The magnitude of $\left(\vec{A} + \vec{B}\right)$ is 'n' times the magnitude of $\left(\vec{A} - \vec{B}\right)$ The angle between $\vec{A}$ and $\vec{B}$ is:
[10 Jan. 2019 II]

Options:

A. $\cos^{-1}\left[\frac{n^2-1}{n^2+1}\right]$

B. $\cos^{-1}\left[\frac{n-1}{n+1}\right]$

C. $\sin^{-1}\left[\frac{n^2-1}{n^2+1}\right]$

D. $\sin^{-1}\left[\frac{n-1}{n+1}\right]$

Answer: A

Solution:

Solution:
Let magnitude of two vectors $\vec{A}$ and $\vec{B} = a$
$|\vec{A}+\vec{B}| = \sqrt{a^2+a^2+2a^2\cos\theta}$ and
$|\vec{A}-B| = \sqrt{a^2+a^2-2a^2[\cos(180°-\theta)]} = \sqrt{a^2+a^2-2a^2\cos\theta}$
and according to question,
$|\vec{A}+\vec{B}| = n|\vec{A}-\vec{B}|$
or, $\frac{a^2+a^2+2a^2\cos\theta}{a^2+a^2-2a^2\cos\theta} = n^2$
$\Rightarrow \frac{(1+\cos\theta)}{(1-\cos\theta)} = n^2$
using componendo and dividendo theorem, we get
$\theta = \cos^{-1}\left[\frac{n^2-1}{n^2+1}\right]$

Question196

A particle moves from the point $\left(2.0\hat{i}+4.0\hat{j}\right)$m, at t = 0, with an initial velocity $\left(5.0\hat{i}+4.0\hat{j}\right)ms^{-1}$. It is acted upon by a constant force which produces a constant acceleration $\left(4.0\hat{i}+4.0\hat{j}\right)ms^{-2}$. What is the distance of the particle from the origin at time 2s?
[11 Jan. 2019 II]

Options:

A. 15 m

B. $20\sqrt{2}$ m

C. 5 m

D. $10\sqrt{2}$ m

Answer: B

Solution:

Solution:
As $\vec{S} = \vec{u}t+\frac{1}{2}\vec{a}t^2$
$\vec{S} = \left(5\hat{i}+4\hat{j}\right)2+\frac{1}{2}\left(4\hat{i}+4\hat{j}\right)4$
$= 10\hat{i}+8\hat{j}+8\hat{i}+8\hat{j}$

$\vec{r}_f - \vec{r}_i = 18\vec{i} + 16\vec{j}$

$[\text{as } \vec{S} = \text{ change in position } = \vec{r}_f - \vec{r}_i]$

$\vec{r}_r = 20\hat{i} + 20\hat{j}$

$|\vec{r}_r| = 20\sqrt{2}$

Question197

A particle is moving with a velocity $\vec{v} = K\left(y\hat{i} + x\hat{j}\right)$ where K is a constant. The general equation for its path is:
[9 Jan. 2019 I]

Options:

A. $y = x^2 +$ constant

B. $y^2 = x +$ constant

C. $y^2 = x^2 +$ constant

D. $xy =$ constant

Answer: C

Solution:

Solution:
From given equation,

$\vec{V} = K\left(y\hat{i} + x\hat{j}\right)$

$\frac{dx}{dt} = ky$ and $\frac{dy}{dt} = kx$

Now $\frac{\frac{dy}{dt}}{\frac{dx}{dt}} = \frac{x}{y} = \frac{dy}{dx}, \Rightarrow y\,dy = x\,dx$

Integrating both side

$y^2 = x^2 + c$

Question198

A body is projected at t = 0 with a velocity $10ms^{-1}$ at an angle of 60° with the horizontal. The radius of curvature of its trajectory at t = 1s is R. Neglecting air resistance and taking acceleration due to gravity $g = 10ms^{-2}$, the value of R is:
[11 Jan. 2019 I]

Options:

A. 10.3 m

B. 2.8 m

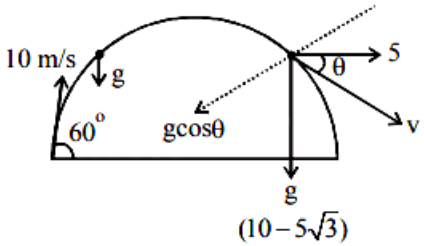
C. 2.5 m

D. 5.1 m

Answer: B

Solution:

Solution:



Horizontal component of velocity
$v_x = 10\cos 60° = 5\text{m/s}$
vertical component of velocity
$v_y = 10\cos 30° = 5\sqrt{3}\text{m/s}$
After t = 1sec
Horizontal component of velocity $v_x = 5\text{m/s}$
Vertical component of velocity
$v_y = |(5\sqrt{3} - 10)|\ \text{m/s} = 10 - 5\sqrt{3}$
Centripetal, acceleration $a_n = \frac{v^2}{R}$
$\Rightarrow R = \frac{v_x^2 + v_y^2}{a_n} = \frac{25 + 100 + 75 - 100\sqrt{3}}{10\cos\theta}$
From figure (using (i))
$\tan\theta = \frac{10 - 5\sqrt{3}}{5} = 2 - \sqrt{3} \Rightarrow \theta = 15°$
$R = \frac{100(2 - \sqrt{3})}{10\cos 15} = 2.8\text{m}$

Question199

Two guns A and B can fire bullets at speeds 1 km/s and 2 km/s respectively. From a point on a horizontal ground, they are fired in all possible directions. The ratio of maximum areas covered by the bullets fired by the two guns, on the ground is: [10 Jan. 2019 I]

Options:

A. 1 : 16

B. 1 : 2

C. 1 : 4

D. 1 : 8

Answer: A

Solution:

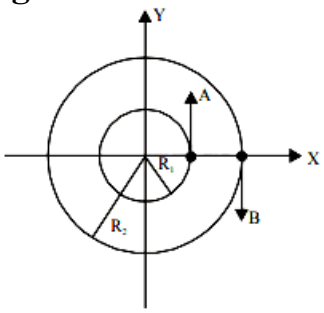
Solution:
As we know, range $R = \frac{u^2 \sin 2\theta}{g}$
and, area $A = \pi R^2$

$\therefore A \propto R^2$ or, $A \propto u^4$

$\therefore \frac{A_1}{A_2} = \frac{u_1^4}{u_2^4} = \left[\frac{1}{2}\right]^4 = \frac{1}{16}$

Question200

Two particles A, B are moving on two concentric circles of radii R_1 and R_2 with equal angular speed omega. At t = 0 their positions and direction of motion are shown in the figure :



The relative velocity $\vec{v}_A - \vec{v}_B$ and $t = \frac{\pi}{2\omega}$ is given by:
[12 Jan. 2019 II]

Options:

A. $\omega(R_1 + R_2)\hat{i}$

B. $-\omega(R_1 + R_2)\hat{i}$

C. $\omega(R_1 - R_2)\hat{i}$

D. $-\omega(R_1 - R_2)\hat{i}$

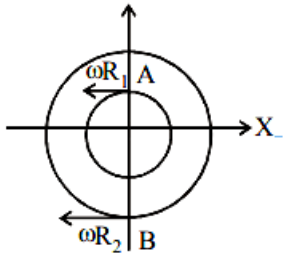
Answer: B

Solution:

Solution:

From, $\theta = \omega t = \omega\frac{\pi}{2\omega} = \frac{\pi}{2}$

So, both have completed quater circle



Relative velocity,

$v_A - v_B = \omega R_1(-\hat{i}) - \omega R_2(-i) = \omega(R_2 - R_1)i$

Question201

A particle is moving with speed $v = b\sqrt{x}$ along positive x-axis. Calculate the speed of the particle at time $t = \tau$ (assume that the particle is at origin at t = 0).
[12 Apr. 2019 II]

Options:

A. $\frac{b^2\tau}{4}$

B. $\frac{b^2\tau}{2}$

C. $b^2\tau$

D. $\frac{b^2\tau}{\sqrt{2}}$

Answer: B

Solution:

Solution:
Given, $v = b\sqrt{x}$
or $\frac{dx}{dt} = bx^{\frac{1}{2}}$
or $\int_0^x x^{-\frac{1}{2}} dx = \int_0^t b\,dt$
or $\frac{x^{\frac{1}{2}}}{\frac{1}{2}} = 6t$ or $x = \frac{b^2t^2}{4}$
Differentiating w. r. t. time, we get
$\frac{dx}{dt} = \frac{b^2 \times 2t}{4}$ or $v = \frac{b^2\tau}{2}$ $(\because t = \tau)$

Question202

A bullet of mass 20g has an initial speed of 1 ms^{-1} , just before it starts penetrating a mud wall of thickness 20 cm. If the wall offers a mean resistance of 2.5×10^{-2} N, the speed of the bullet after emerging from the other side of the wall is close to :
[10 Apr. 2019 II]

Options:

A. 0.1 ms^{-1}

B. 0.7 ms^{-1}

C. 0.3 ms^{-1}

D. 0.4 ms^{-1}

Answer: B

Solution:

Solution:
From the third equation of motion
$v^2 - u^2 = 2aS$
But, $a = \frac{F}{m}$
$\therefore v^2 = u^2 - 2\left(\frac{F}{m}\right)S$
$\Rightarrow v^2 = (1)^2 - (2)\left[\frac{2.5 \times 10^{-2}}{20 \times 10^{-3}}\right]\frac{20}{100}$
$\Rightarrow v^2 = 1 - \frac{1}{2}$
$\Rightarrow v = \frac{1}{\sqrt{2}} m/s = 0.7 m/s$

Question203

The position of a particle as a function of time t, is given by $x(t) = at + bt^2 - ct^3$ where, a, b and c are constants. When the particle attains zero acceleration, then its velocity will be:
[9 Apr. 2019 II]

Options:

A. $a + \frac{b^2}{4c}$

B. $a + \frac{b^2}{3c}$

C. $a + \frac{b^2}{c}$

D. $a + \frac{b^2}{2c}$

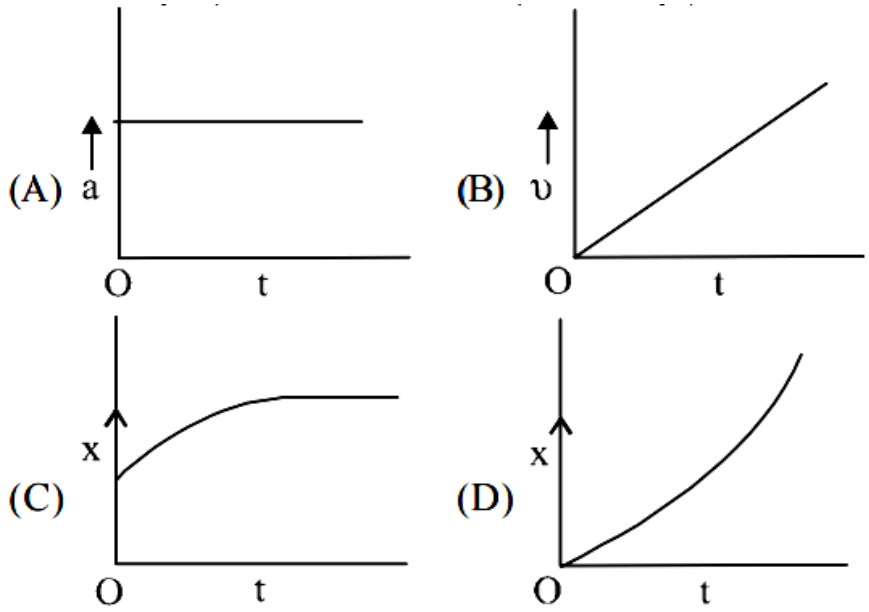
Answer: B

Solution:

Solution:
$x = at + bt^2 - ct^3$
Velocity, $v = \frac{dx}{dt} = \frac{d}{dt}(at + bt^2 + ct^3)$
$= a + 2bt - 3ct^2$
Acceleration, $\frac{dv}{dt} = \frac{d}{dt}(a + 2bt - 3ct^2)$
or $0 = 2b - 3c \times 2t$
$\therefore t = \left(\frac{b}{3c}\right)$
and $v = a + 2b\left(\frac{b}{3c}\right) - 3c\left(\frac{b}{3c}\right)^2 = \left(a + \frac{b^2}{3c}\right)$

Question204

A particle starts from origin O from rest and moves with a uniform acceleration along the positive x-axis. Identify all figures that correctly represents the motion qualitatively (a = acceleration, v = velocity, x = displacement, t = time)



[8 Apr. 2019 II]

Options:

A. (B), (C)

B. (A)

C. (A), (B), (C)

D. (A), (B), (D)

Answer: D

Solution:

Solution:
For constant acceleration, there is straight line
parallel to t-axis on $\vec{a} - t$.
Inclined straight line on $\vec{v} - t$, and parabola on $\vec{x} - t$

Question205

The position vector of a particle changes with time according to the relation $\vec{r}(t) = 15t^2\hat{i} + (4 - 20t^2)\hat{j}$. What is the magnitude of the acceleration at t = 1?
[9 April 2019 II]

Options:

A. 40

B. 25

C. 100

D. 50

Answer: D

Solution:

Solution:
$\vec{r}(t) = 15t^2\hat{i} + (4 - 20t^2)\hat{j}$
$\vec{v} = \frac{d\vec{r}}{dt} = 30t\hat{i} - 40\hat{t}$
Acceleration, $\vec{a} = \frac{d\vec{v}}{dt} = 30\hat{i} - 40\hat{j}$
$\therefore a = \sqrt{30^2 + 40^2} = 50 m/s^2$

Question206

The trajectory of a projectile near the surface of the earth is given as $y = 2x - 9x^2$. If it were launched at an angle θ_0 with speed v_0 then ($g = 10ms^{-2}$)
[12 April 2019 I]

Options:

A. $\theta_0 = \sin^{-1}\frac{1}{\sqrt{5}}$ and $v_0 = \frac{5}{3}ms^{-1}$

B. $\theta_0 = \cos^{-1}\left(\frac{2}{\sqrt{5}}\right)$ and $v_0 = \frac{3}{5}ms^{-1}$

C. $\theta_0 = \cos^{-1}\left(\frac{1}{\sqrt{5}}\right)$ and $v_0 = \frac{9}{3}ms^{-1}$

D. $\theta_0 = \sin^{-1}\left(\frac{2}{\sqrt{5}}\right)$ and $v_0 = \frac{3}{5}ms^{-1}$

Answer: C

Solution:

Solution:
Given, $y = 2x - 9x^2$
On comparing with,

$y = x\tan\theta - \frac{gx^2}{2u^2\cos^2\theta}$,

We have,

$\tan\theta = 2$ or $\cos\theta = \frac{1}{\sqrt{5}}$

and $\frac{g}{2u^2\cos^2\theta} = 9$ or $\frac{10}{2u^2(1/\sqrt{5})^2} = 9$

$\therefore u = \frac{5}{3}m/s$

Question207

A shell is fired from a fixed artillery gun with an initial speed u such that it hits the target on the ground at a distance R from it. If t_1 and t_2 are the values of the time taken by it to hit the target in two possible ways, the product t_1t_2 is :
[12 April 2019 I]

Options:

A. $R/4g$

B. R/g

C. $R/2g$

D. $2R/g$

Answer: D

Solution:

Solution:
R will be same for theta and $90° - \theta$.
Time of flights:

$t_1 = \frac{2u\sin\theta}{g}$ and

$t_2 = \frac{2u\sin(90° - \theta)}{g} = \frac{2u\cos\theta}{g}$

Now, $t_1t_2 = \left(\frac{2u\sin\theta}{g}\right)\left(\frac{2u\cos\theta}{g}\right)$

$= \frac{2}{g}\left(\frac{u^2\sin 2\theta}{g}\right) = \frac{2R}{g}$

Question208

Two particles are projected from the same point with the same speed u such that they have the same range R, but different maximum heights, h_1 and h_2. Which of the following is correct?
[12 April 2019 II]

Options:

A. $R^2 = 4h_1h_2$

B. $R^2 = 16h_1h_2$

C. $R^2 = 2h_1h_2$

D. $R^2 = h_1h_2$

Answer: B

Solution:

Solution:
For same range, the angle of projections are : θ and $90° - \theta$. So,

$h_1 = \frac{u^2\sin^2\theta}{2g}$ and

$h_2 = \frac{u^2\sin^2(90° - \theta)}{2g} = \frac{u^2\cos^2\theta}{2g}$

Also, $R = \frac{u^2 \sin 2\theta}{g}$

$h_1h_2 = \frac{u^2\sin^2\theta}{2g} \times \frac{u^2\cos^2\theta}{2g}$

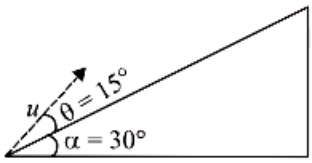
$= \frac{u^2}{16}\frac{u^2(2\sin\theta\cos\theta)^2}{g^2}$

$= \frac{R^2}{16}$

or $R^2 = 16h_1h_2$

Question209

A plane is inclined at an angle $\alpha = 30°$ with respect to the horizontal. A particle is projected with a speed $u = 2ms^{-1}$, from the base of the plane, as shown in figure. The distance from the base, at which the particle hits the plane is close to: (Take $g = 10ms^{-2}$)



[10 April 2019 II]

Options:

A. 20 cm

B. 18 cm

C. 26 cm

D. 14 cm

Answer: A

Solution:

Solution:

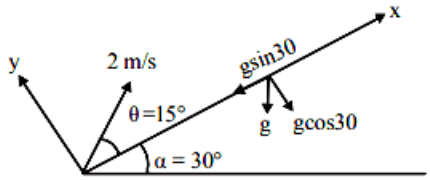
On an inclined plane, time of flight (T) is given by

$T = \frac{2u\sin\theta}{g\cos\alpha}$

Substituting the values, we get

$T = \frac{(2)(2\sin 15°)}{g\cos 30°} = \frac{4\sin 15°}{10\cos 30°}$

Distance, $S = (2\cos 15°)T - \frac{1}{2}g\sin 30°(T)^2$



$= (2\cos 15°)\frac{4}{10}\frac{\sin 15°}{10\cos 30°} - \left(\frac{1}{2}\times 10\sin 30°\right)\frac{16\sin^2 15°}{100\cos^2 30°}$

$= \frac{16\sqrt{3}-16}{60} \simeq 0.1952\text{m} \simeq 20\text{cm}$

Question210

The stream of a river is flowing with a speed of 2 km/h. A swimmer can swim at a speed of 4 km/h. What should be the direction of the swimmer with respect to the flow of the river to cross the river straight?
[9 April 2019 I]

Options:

A. 90°

B. 150°

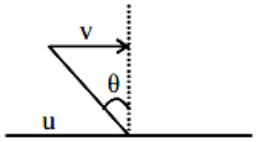
C. 120°

D. 60°

Answer: C

Solution:

Solution:



$\sin\theta = \frac{u}{v} = \frac{2}{4} = \frac{1}{2}$

or $\theta = 30°$

with respect to flow,

$= 90° + 30° = 120°$

Question211

Ship A is sailing towards north-east with velocity km/hr where points east and , north. Ship B is at a distance of 80 km east and 150 km north of Ship A and is sailing towards

west at 10 km/hr. A will be at minimum distance from B in:
[8 April 2019 I]

Options:

A. 4.2 hrs.

B. 2.6 hrs.

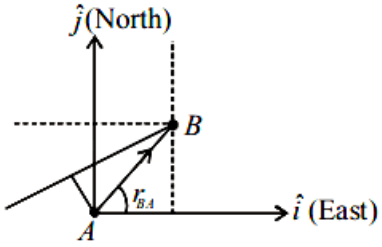
C. 3.2 hrs.

D. 2.2 hrs

Answer: B

Solution:

Solution:



$\vec{v}_A = 30\hat{i} + 50\hat{j}\,km/hr$

$\vec{v}_B = (-10\hat{i})\,km/hr$

$r_{BA} = (80\hat{i} + 150\hat{j})\,km$

$\vec{v}_{BA} = \vec{v}_B - \vec{v}_A = -10\hat{i} - 30\hat{i} - 50\hat{i} = 40\hat{i} - 50\hat{j}$

$$t_{minimum} = \frac{|(\vec{r}_{BA}) \cdot (\vec{v}_{BA})|}{|(\vec{v}_{BA})|^2}$$

$$= \frac{|(80\hat{i} + 150\hat{j})(-40\hat{i} - 50\hat{j})|}{(10\sqrt{41})^2}$$

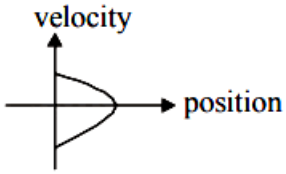
$$\therefore t = \frac{10700}{10\sqrt{41} \times 10\sqrt{41}} = \frac{107}{41} = 2.6\,hrs$$

Question212

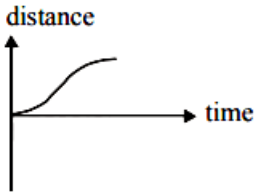
All the graphs below are intended to represent the same motion. One of them does it incorrectly. Pick it up.
[2018]

Options:

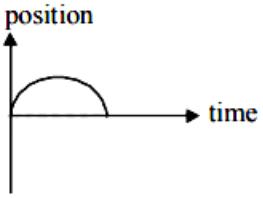
A.



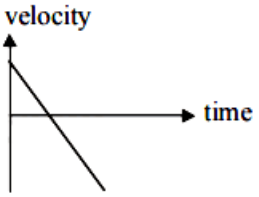
B.



C.



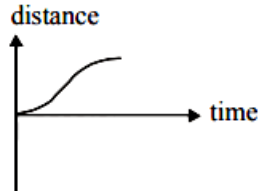
D.



Answer: B

Solution:

Solution:
Graphs in option (c) position-time and option (a) velocity-position are corresponding to velocity-time graph option (d) and its distance-time graph is as given below.
Hence distance-time graph option (b) is incorrect.



Question213

An automobile, travelling at 40 km/h, can be stopped at a distance of 40 m by applying brakes. If the same automobile is travelling at 80 km/h, the minimum stopping distance, in metres, is (assume no skidding) [Online April 15, 2018]

Options:

A. 75 m

B. 160 m

C. 100 m

D. 150 m

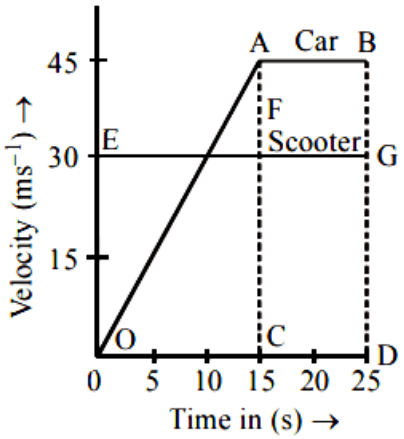
Answer: B

Solution:

Solution:
According to question,
$u_1 = 40\,km/h$, $v_1 = 0$ and $s_1 = 40m$
using $v^2 - u^2 = 2as$; $0^2 - 40^2 = 2a \times 40$ ....(i)
Again, $0^2 - 80^2 = 2as$ ...(ii)
From eqn. (i) and (ii)
Stopping distance, $s = 160m$

Question214

The velocity-time graphs of a car and a scooter are shown in the figure. (i) the difference between the distance travelled by the car and the scooter in 15 s and (ii) the time at which the car will catch up with the scooter are, respectively



[Online April 15, 2018]

Options:

A. 337.5m and 25s

B. 225.5m and 10s

C. 112.5m and 22.5s

D. 11.2.5m and 15s

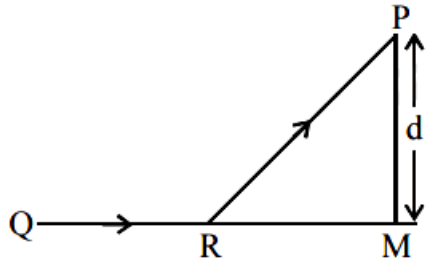
Answer: C

Solution:

Solution:
Using equation, $a = \frac{v-u}{t}$ and $S = ut + \frac{1}{2}at^2$
Distance travelled by car in 15 sec $= \frac{1}{2}\frac{(45)}{15}(15)^2 = \frac{675}{2}m$
Distance travelled by scooter in 15 seconds = 30 × 15 = 450
(∵ distance = speed × time)
Difference between distance travelled by car and scooter in 15 sec, 450 – 337.5 = 112.5 m
Let car catches scooter in time t;
$\frac{675}{2} + 45(t-15) = 30t$
$\Rightarrow 337.5 + 45t - 675 = 30t$
$\Rightarrow 15t = 337.5$
$\Rightarrow t = 22.5\,sec$

Question215

A man in a car at location Q on a straight highway is moving with speed v. He decides to reach a point P in a field at a distance d from highway (point M) as shown in the figure. Speed of the car in the field is half to that on the highway. What should be the distance RM, so that the time taken to reach P is minimum?



[Online April 15, 2018]

Options:

A. $\frac{d}{\sqrt{3}}$

B. $\frac{d}{2}$

C. $\frac{d}{\sqrt{2}}$

D. d

Answer: A

Solution:

Solution:
Let the car turn of the highway at a distance 'x' from the point M. So, RM = x
And if speed of car in field is v, then time taken by the car to cover the distance QR = QM – x on the highway,

$t_1 = \frac{QM - x}{2v}$ ....(i)

Time taken to travel the distance 'RP' in the field

$t_2 = \frac{\sqrt{d^2 + x^2}}{v}$ ...(ii)

Total time elapsed to move the car from Q to P

$t = t_1 + t_2 = \frac{QM - x}{2v} + \frac{\sqrt{d^2 + x^2}}{v}$

For 't' to be minimum $\frac{dt}{dx} = 0$

$\frac{1}{v}\left[-\frac{1}{2} + \frac{x}{\sqrt{d^2 + x^2}}\right] = 0$

or $x = \frac{d}{\sqrt{2^2 - 1}} = \frac{d}{\sqrt{3}}$

Question216

Let $\vec{A} = \left(\hat{i} + \hat{j}\right)$ and $\vec{B} = \left(\hat{i} - \hat{j}\right)$. The magnitude of a coplanar vector $\vec{C}$ such that $\vec{A} \cdot \vec{C} = \vec{B} \cdot \vec{C} = \vec{A} \cdot \vec{B}$ is given by
[Online April 16,2018]

Options:

A. $\sqrt{\frac{5}{9}}$

B. $\sqrt{\frac{10}{9}}$

C. $\sqrt{\frac{20}{9}}$

D. $\sqrt{\frac{9}{12}}$

Answer: A

Solution:

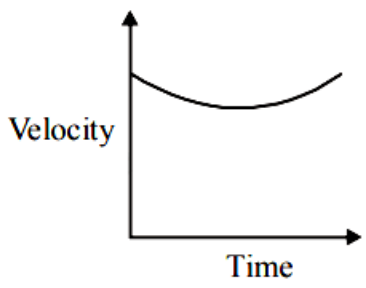
Solution:
If $\vec{C} = a\hat{i} + b\hat{j}$ then $\vec{A} \cdot \vec{C} = \vec{A} \cdot \vec{B}$
$a + b = 1$ ....(i)
$\vec{B} \cdot \vec{C} = \vec{A} \cdot \vec{B}$
$2a - b = 1$ ....(ii)
Solving equation (i) and (ii) we get
$a = \frac{1}{3}, b = \frac{2}{3}$
∴ Magnitude of coplanar vector, $|\vec{C}| = \sqrt{\frac{1}{9} + \frac{4}{9}} = \sqrt{\frac{5}{9}}$

Question217

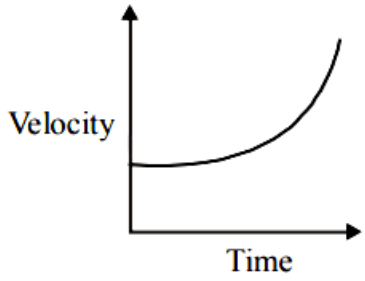
Which graph corresponds to an object moving with a constant negative acceleration and a positive velocity ?
[Online April 8, 2017]

Options:

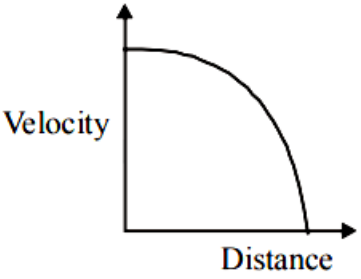
A.



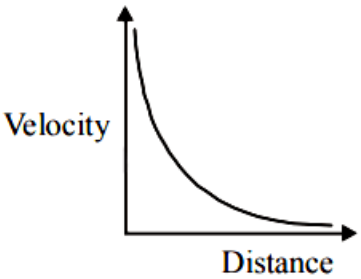
B.



C.



D.



Answer: C

Solution:

Solution:
According to question, object is moving with constant negative acceleration i.e., a = – constant (C)

$$\frac{v\,dv}{dx} = -C$$

$$v\,dv = -C\,dx$$

$$\frac{v^2}{2} = -Cx + k$$

$$x = -\frac{v^2}{2C} + \frac{k}{C}$$

Hence, graph (3) represents correctly

Question218

A car is standing 200 m behind a bus, which is also at rest. The two start moving at the same instant but with different forward accelerations. The bus has acceleration 2 m/s^2 and the car has acceleration 4 m/s^2. The car will catch up with the bus after a time of : [Online April 9, 2017]

Options:

A. $\sqrt{110}$ s

B. $\sqrt{120}$ s

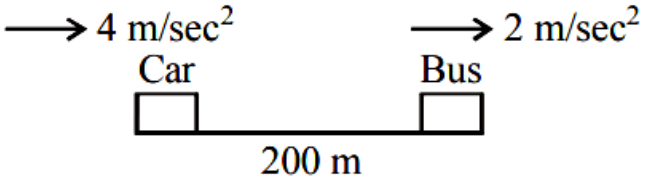
C. $10\sqrt{2}$ s

D. 15 s

Answer: C

Solution:

Solution:



Given, $u_c = u_B = 0$, $a_c = 4m/s^2$, $a_B = 2m/s^2$

hence relative acceleration, $a_{CB} = 2m/sec^2$

Now, we know, $s = ut + \frac{1}{2}at^2$

$200 = \frac{1}{2} \times 2t^2 \because u = 0$

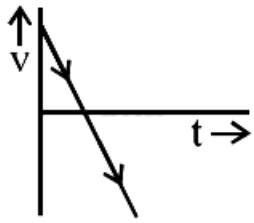
Hence, the car will catch up with the bus after time
$t = 10\sqrt{2}$ second

Question219

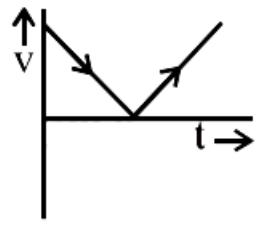
A body is thrown vertically upwards. Which one of the following graphs correctly represent the velocity vs time?
[2017]

Options:

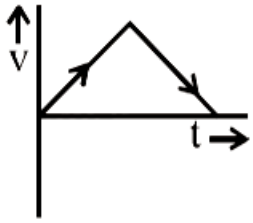
A.



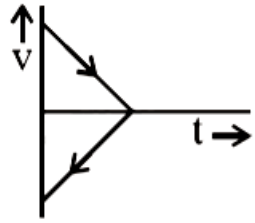
B.



C.



D.



Answer: A

Solution:

Solution:
For a body thrown vertically upwards acceleration remains constant (a = – g) and velocity at anytime t is given by V = u – gt
During rise velocity decreases linearly and during fall velocity increases linearly and direction is opposite to each other.
Hence graph (a) correctly depicts velocity versus time.

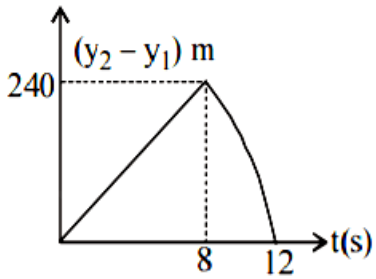
Question220

Two stones are thrown up simultaneously from the edge of a cliff 240 m high with initial speed of 10 m/s and 40 m/s respectively. Which of the following graph best represents the time variation of relative position of the second stone with respect to the first ?
(Assume stones do not rebound after hitting the ground and neglect air resistance, take g = 10 m/ s^2)
[2015]

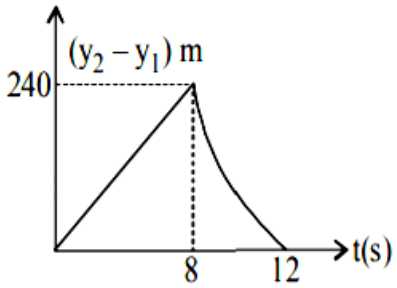
(The figures are schematic and not drawn to scale)

Options:

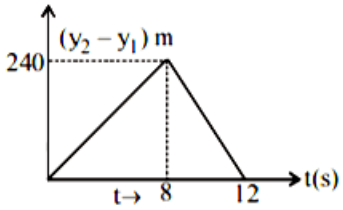
A.



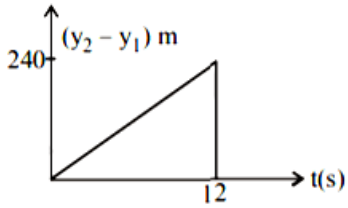
B.



C.



D.



Answer: B

Solution:

Solution:
$y_1 = 10t - 5t^2$; $y_2 = 40t - 5t^2$
for $y_1 = -240$m, $t = 8$s
$\therefore y_2 - y_1 = 30t$ for $t \leq 8$s
for $t > 8$s
$y_2 - y_1 = 240 - 40t - \frac{1}{2}gt^2$

Question221

A vector $\vec{A}$ is rotated by a small angle Delta theta radian ($\Delta\theta << 1$) to get a new vector $\vec{B}$. In that case $\left|\vec{B} - \vec{A}\right|$ is :
[Online April 11, 2015]

Options:

A. $\left|\vec{A}\right|\Delta\theta$

B. $\left|\vec{B}\right|\Delta\theta - \left|\vec{A}\right|$

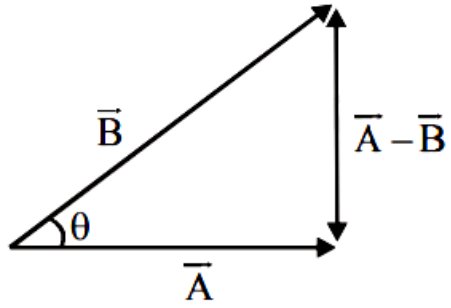
C. $\left|\vec{A}\right|\left(1 - \frac{\Delta\theta^2}{2}\right)$

D. 0

Answer: A

Solution:

Solution:
Arc length = radius × angle
So, $|\vec{B}-\vec{A}| = |\vec{A}|\Delta\theta$



Question222

A particle is moving along a circular path with a constant speed of 10 ms^{-1}. What is the magnitude of the change in velocity of the particle, when it moves through an angle of 60° around the centre of the circle?
[Online April 10, 2015]

Options:

A. $10\sqrt{3}$ m/s

B. zero

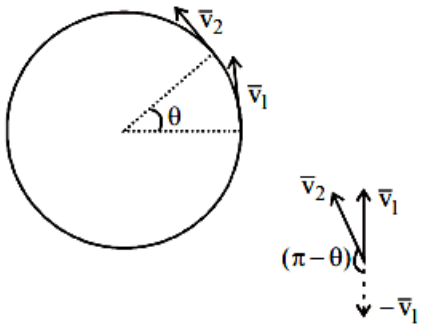
C. $10\sqrt{2}$ m/s

D. 10 m/s

Answer: D

Solution:

Solution:



Change in velocity,
$|\Delta\vec{v}| = \sqrt{v_1^2 + v_2^2 + 2v_1v_2\cos(\pi-\theta)}$
$= 2v\sin\frac{\theta}{2}\left(\because |\vec{v}_1| = |\vec{v}_2|\right) = v$

$= (2 \times 10) \times \sin(30°) = 2 \times 10 \times \frac{1}{2}$

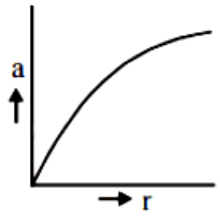
$= 10 m/s$

Question223

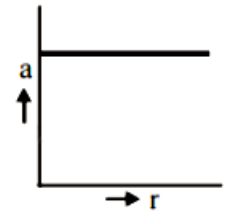
If a body moving in circular path maintains constant speed of 10 ms^{-1}, then which of the following correctly describes relation between acceleration and radius? [Online April 10, 2015]

Options:

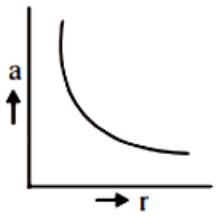
A.



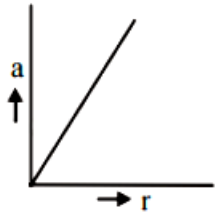
B.



C.



D.



Answer: C

Solution:

Solution:
Speed, V = constant (from question)
Centripetal acceleration,

$a = \frac{V^2}{r}$

$ra =$ constant Hence graph (c) correctly describes relation between acceleration and radius.

Question224

A person climbs up a stalled escalator in 60 s. If standing on the same but escalator running with constant velocity he takes 40 s. How much time is taken by the person to walk up the moving escalator?
[Online April 12, 2014]

Options:

A. 37 s

B. 27 s

C. 24 s

D. 45 s

Answer: C

Solution:

Solution:

Person's speed walking only is $\frac{1}{60}\frac{\text{escalator}}{\text{second}}$

Standing the escalator without walking the speed is $\frac{1}{40}\frac{\text{escalator}}{\text{second}}$

Walking with the escalator going, the speed add.

So, the person's speed is $\frac{1}{60}+\frac{1}{40}=\frac{15}{120}\frac{\text{escalator}}{\text{second}}$

So, the time to go up the escalator $t=\frac{120}{5}=24\,\text{second}$

Question225

From a tower of height H, a particle is thrown vertically upwards with a speed u. The time taken by the particle, to hit the ground, is n times that taken by it to reach the highest point of its path. The relation between H, u and n is:
[2014]

Options:

A. $2gH = n^2u^2$

B. $gH = (n-2)^2u^2d$

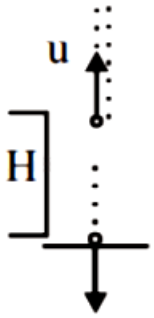
C. $2gH = nu^2(n-2)$

D. $gH = (n-2)u^2$

Answer: C

Solution:

Solution:



Speed on reaching ground

$v = \sqrt{u^2 + 2gh}$

Now, $v = u + at$

$\Rightarrow \sqrt{u^2 + 2gh} = -u + gt$

Time taken to reach highest point is $t = \frac{u}{g}$

$\Rightarrow t = \frac{u + \sqrt{u^2 + 2gH}}{g} = \frac{nu}{g}$

(from question)

$\Rightarrow 2gH = n(n-2)u^2$

Question226

The initial speed of a bullet fired from a rifle is 630 m/s. The rifle is fired at the centre of a target 700 m away at the same level as the target. How far above the centre of the target ?
[Online April 11, 2014]

Options:

A. 1.0 m

B. 4.2 m

C. 6.1 m

D. 9.8 m

Answer: C

Solution:

Solution:

Let ' t ' be the time taken by the bullet to hit the target.

$\therefore 700m = 630ms^{-1}t$

$\Rightarrow t = \frac{700m}{630ms^{-1}} = \frac{10}{9}sec$

For vertical motion,

Here, $u = 0$

$\therefore h = \frac{1}{2}gt^2$

$= \frac{1}{2} \times 10 \times \left(\frac{10}{9}\right)^2$

$= \frac{500}{81}\text{m} = 6.1\text{m}$

Therefore, the rifle must be aimed 6.1m above the centre of the target to hit the target.

Question227

The position of a projectile launched from the origin at t = 0 is given by $\vec{r} = \left(40\hat{i} + 50\hat{j}\right)$m at t = 2s. If the projectile was launched at an angle theta from the horizontal, then θ is (take g = 10ms^{-2})
[Online April 9, 2014]

Options:

A. $\tan^{-1}\frac{2}{3}$

B. $\tan^{-1}\frac{3}{2}$

C. $\tan^{-1}\frac{7}{4}$

D. $\tan^{-1}\frac{4}{5}$

Answer: C

Solution:

Solution:
From question,
Horizontal velocity (initial),

$u_x = \frac{40}{2} = 20\text{m/s}$

Vertical velocity (initial), $50 = u_y t + \frac{1}{2}gt^2$

$\Rightarrow u_y \times 2 + \frac{1}{2}(-10) \times 4$

or, $50 = 2u_y - 20$

or, $u_y = \frac{70}{2} = 35\text{m/s}$

$\therefore \tan\theta = \frac{u_y}{u_x} = \frac{35}{20} = \frac{7}{4}$

$\Rightarrow$ Angle $\theta = \tan^{-1}\frac{7}{4}$

Question228

A projectile is given an initial velocity of $\left(\hat{i} + 2\hat{j}\right)$m/swhere $\hat{i}$ is along the ground and $\hat{j}$ is along the vertical. If g = 10m/s^2, the equation of its trajectory is:
[2013]

Options:

A. $y = x - 5x^2$

B. $y = 2x - 5x^2$

C. $4y = 2x - 5x^2$

D. $4y = 2x - 25x^2$

Answer: B

Solution:

Solution:
From equation, $\vec{v} = \hat{i} + 2\hat{j}$
$\Rightarrow x = t$ .....(i)
$y = 2t - \frac{1}{2}(10t^2)$.....(ii)
From (i) and (ii), $y = 2x - 5x^2$

Question229

The maximum range of a bullet fired from a toy pistol mounted on a car at rest is R_0 = 40 m. What will be the acute angle of inclination of the pistol for maximum range when the car is moving in the direction of firing with uniform velocity v = 20 m/s, on a horizontal surface ? (g = 10 m/s^2)
[Online April 25, 2013]

Options:

A. 30°

B. 60°

C. 75°

D. 45°

Answer: B

Solution:

Solution:

Question230

A ball projected from ground at an angle of 45° just clears a wall in front. If point of projection is 4 m from the foot of wall and ball strikes the ground at a distance of 6 m on the other side of the wall, the height of the wall is :
[Online April 22, 2013]

Options:

A. 4.4 m

B. 2.4 m

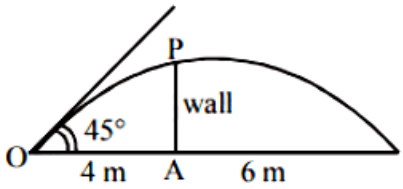
C. 3.6 m

D. 1.6 m

Answer: B

Solution:

Solution:



As ball is projected at an angle $45°$ to the horizontal therefore Range $= 4H$

or $10 = 4H \Rightarrow H = \frac{10}{4} = 2.5\text{m}$

$(\because$ Range $= 4\text{m} + 6\text{m} = 10\text{m})$

Maximum height, $H = \frac{u^2\sin^2\theta}{2g}$

$\therefore u^2 = \frac{H \times 2g}{\sin^2\theta} = \frac{2.5 \times 2 \times 10}{\left(\frac{1}{\sqrt{2}}\right)^2} = 100$

or, $u = \sqrt{100} = 10\text{ms}^{-1}$

Height of wall PA

$= \text{OA}\tan\theta - \frac{1}{2}\frac{g(\text{OA})^2}{u^2\cos^2\theta}$

$= 4 - \frac{1}{2} \times \frac{10 \times 16}{10 \times 10 \times \frac{1}{\sqrt{2}} \times \frac{1}{\sqrt{2}}} = 2.4\text{m}$

Question231

A car covers the first half of the distance between two places at 40 km/h and other half at 60 km/h. The average speed of the car is [Online May 7, 2012]

Options:

A. 40 km/h

B. 45 km/h

C. 48 km/h

D. 60 km/h

Answer: C

Solution:

Solution:

Average speed $= \frac{\text{Total distance travelled}}{\text{Total time taken}} = \frac{x}{T}$

$= \frac{x}{\frac{x}{2\times 40}+\frac{x}{2\times 60}}$ = 48 km/h

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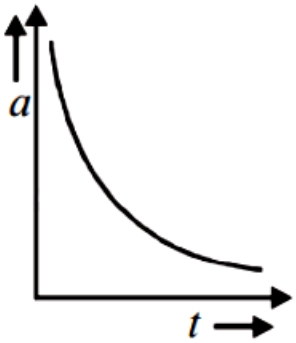
Question232

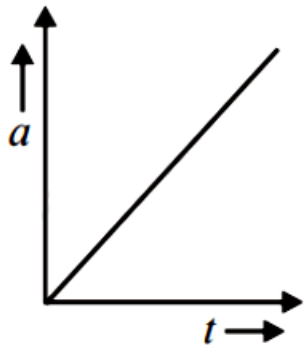
The distance travelled by a body moving along a line in time t is proportional to t^3. The acceleration-time (a, t) graph for the motion of the body will be
[Online May 12, 2012]

Options:

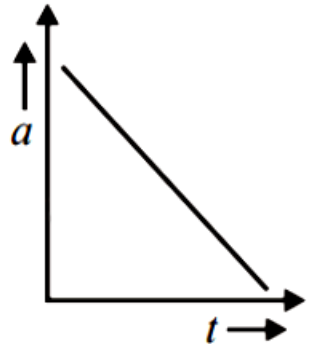
A.



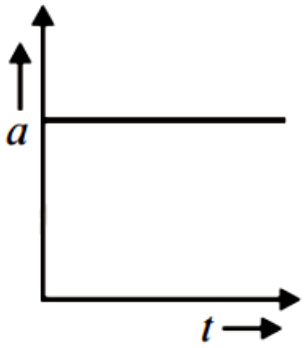
B.



C.



D.



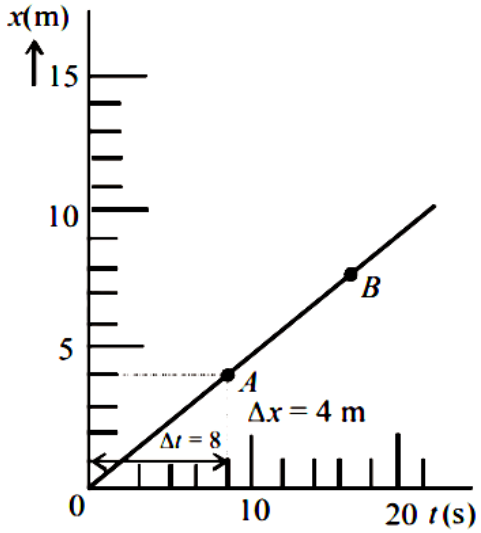
Answer: B

Solution:

Solution:
Distance along a line i.e., displacement (s) $= t^3$ ($\because s \propto t^3$ given)
By double differentiation of displacement, we get acceleration.
$V = \frac{ds}{dt} = \frac{dt^3}{dt} = 3t^2$ and $a = \frac{dv}{dt} = \frac{d\,3t^2}{dt} = 6t$
$a = 6t$ or $a \propto t$
Hence graph (b) is correct.

Question233

The graph of an object's motion (along the x-axis) is shown in the figure. The instantaneous velocity of the object at points A and B are v_A and v_B respectively. Then



[Online May 7, 2012]

Options:

A. $v_A = v_B = 0.5 m/s$

B. $v_A = 0.5 m/s < v_B$

C. $v_A = 0.5 m/s > v_B$

D. $v_A = v_B = 2 m/s$

Answer: A

Solution:

Solution:
Instantaneous velocity $v = \frac{\Delta x}{\Delta t}$
From graph, $v_A = \frac{\Delta x_A}{\Delta t_A} = \frac{4m}{8s} = 0.5m/s$
and $v_B = \frac{\Delta x_B}{\Delta t_B} = \frac{8m}{16s} = 0.5m/s$
i.e., $v_A = v_B = 0.5m/s$

Question234

A goods train accelerating uniformly on a straight railway track, approaches an electric pole standing on the side of track. Its engine passes the pole with velocity u and the guard's room passes with velocity v. The middle wagon of the train passes the pole with a velocity.
[Online May 19, 2012]

Options:

A. $\frac{u+v}{2}$

B. $\frac{1}{2}\sqrt{u^2+v^2}$

C. $\sqrt{uv}$

D. $\sqrt{\left(\frac{u^2+v^2}{2}\right)}$

Answer: D

Solution:

Solution:
Let 'S' be the distance between two ends 'a' be the constant acceleration
As we know $v^2 - u^2 = 2aS$
or, $aS = \frac{v^2-u^2}{2}$
Let v be velocity at mid point
Therefore, $v_c^2 - u^2 = 2a\frac{S}{2}$
$v_c^2 = u^2 + aS$
$v_c^2 = u^2 + \frac{v^2-u^2}{2}$
$v_c = \sqrt{\frac{u^2+v^2}{2}}$

Question235

A boy can throw a stone up to a maximum height of 10 m.
The maximum horizontal distance that the boy can throw the same stone up to will be
[2012]

Options:

A. $20\sqrt{2}$ m

B. 10 m

C. $10\sqrt{2}$ m

D. 20 m

Answer: D

Solution:

Solution:
$R = \frac{u^2 \sin^2\theta}{g}, H = \frac{u^2 \sin^2\theta}{2g}$
H_{max} at $2\theta = 90°$
$H_{max} = \frac{u^2}{2g}$
$\frac{u^2}{2g} = 10 \Rightarrow u^2 = 10g \times 2$
$R = \frac{u^2 \sin 2\theta}{g} \Rightarrow R_{max} = \frac{u^2}{g}$
$R_{max} = \frac{10 \times g \times 2}{g} = 20$ metre

Question236

An object, moving with a speed of 6.25m/s, is decelerated at a rate given by $\frac{dv}{dt} = -2.5\sqrt{v}$ where v is the instantaneous speed. The time taken by the object, to come to rest, would be:
[2011]

Options:

A. 2 s

B. 4 s

C. 8 s

D. 1 s

Answer: A

Solution:

Solution:

Given, $\frac{dv}{dt} = -2.5\sqrt{v}$

$\Rightarrow \frac{dv}{\sqrt{v}} = -2.5dt$

Integrating

$\int_{6.25}^{0} v^{-\frac{1}{2}} dv = -2.5 \int_{0}^{t} dt$

$\Rightarrow \left[\frac{v^{+\frac{1}{2}}}{\left(\frac{1}{2}\right)} \right]_{6.25}^{0} = -2.5[t]_0^t$

$\Rightarrow -2(6.25)^{\frac{1}{2}} = -2.5t$

$\Rightarrow -2 \times 2.5 = -2.5t$

$\Rightarrow t = 2s$

Question237

A water fountain on the ground sprinkles water all around it. If the speed of water coming out of the fountain is v, the total area around the fountain that gets wet is: [2011]

Options:

A. $\pi\frac{v^4}{g^2}$

B. $\frac{\pi}{2}\frac{v^4}{g^2}$

C. $\pi\frac{v^2}{g^2}$

D. $\pi\frac{v^2}{g}$

Answer: A

Solution:

Solution:
Let, total area around fountain
$A = \pi R_{max}^{\ 2}$ .....(i)
Where $R_{max} = \frac{v^2 \sin 2\theta}{g} = \frac{v^2 \sin 90°}{g} = \frac{v^2}{g}$.....(ii)
From equation (i) and (ii)
$A = \pi\frac{v^4}{g^2}$

Question238

A particle is moving with velocity $\vec{v} = k\left(y\hat{i} + x\hat{j}\right)$, where k is a constant. The general equation for its path is [2010]

Options:

A. $y = x^2 + \text{constant}$

B. $y^2 = x + \text{constant}$

C. $xy = \text{constant}$

D. $y^2 = x^2 + \text{constant}$

Answer: D

Solution:

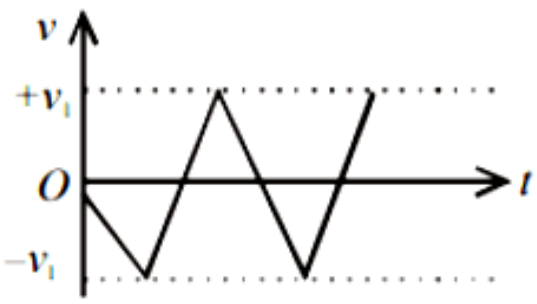
Solution:
$v = k(yi + xj)$
$v = kyi + kxj$
$\frac{dx}{dt} = ky, \frac{dy}{dt} = kx$
$\frac{dy}{dx} = \frac{dy}{dt} \times \frac{dt}{dx}$
$\frac{dy}{dx} = \frac{kx}{ky}$
$y\,dy = x\,dx$ .....(i)
Integrating equation (i)
$\int y\,dy = \int x\,.\,dx$
$y^2 = x^2 + c$

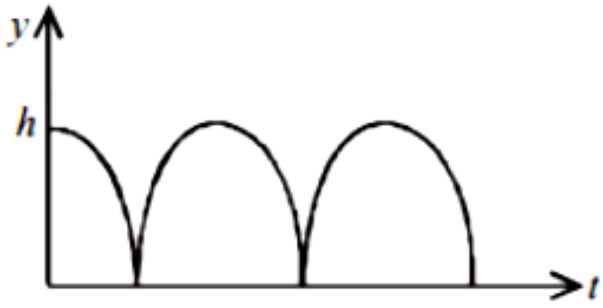
Question239

Consider a rubber ball freely falling from a height h = 4.9 m onto a horizontal elastic plate. Assume that the duration of collision is negligible and the collision with the plate is totally elastic.
Then the velocity as a function of time and the height as a function of time will be : [2009]

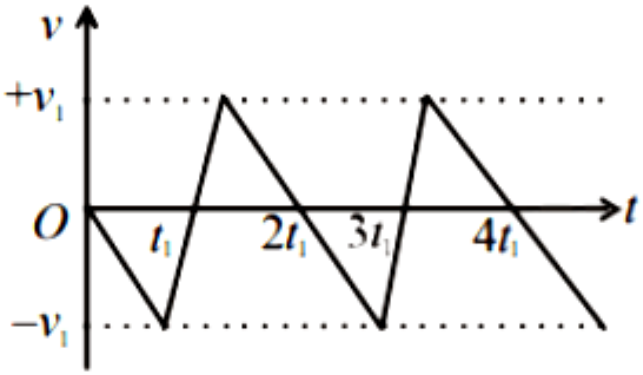
Options:

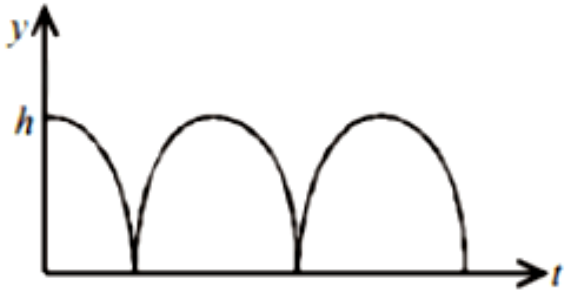
A.



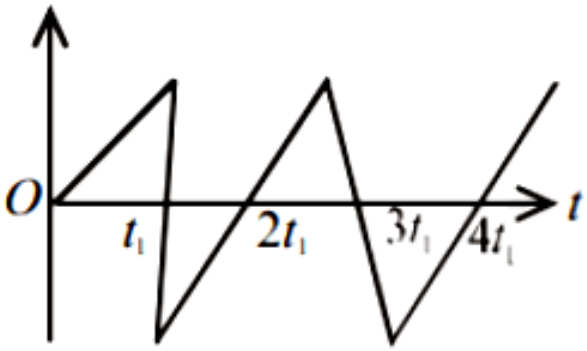


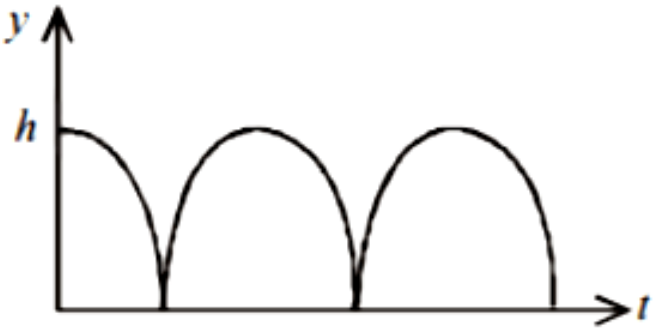
B.



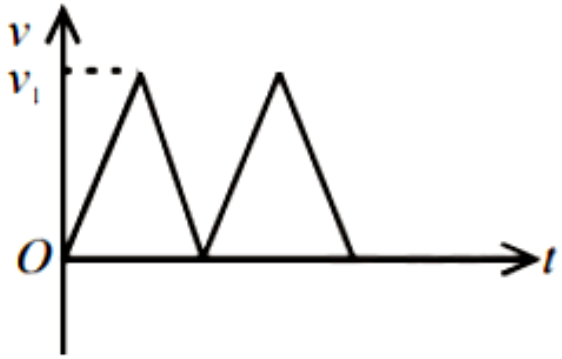


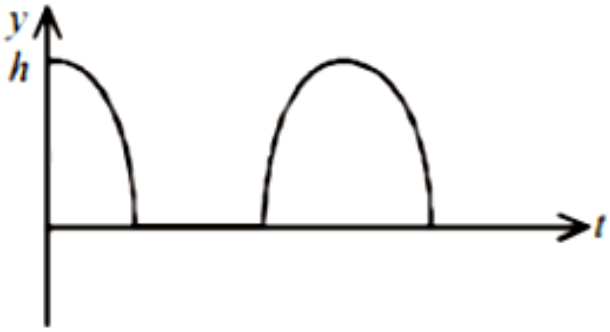
C.





D.





Answer: B

Solution:

Solution:
For downward motion v = –gt
The velocity of the rubber ball increases in downward direction and we get a straight line between v and t with a negative slope.

Also applying $y - y_0 = ut + \frac{1}{2}at^2$

We get $y - h = -\frac{1}{2}gt^2 \Rightarrow y = h - \frac{1}{2}gt^2$

The graph between y and t is a parabola with y = h at t = 0.
As time increases y decreases.
For upward motion.
The ball suffer elastic collision with the horizontal elastic plate therefore the direction of velocity is reversed and the magnitude remains the same.
Here v = u – gt where u is the velocity just after collision.
As t increases, v decreases. We get a straight line between v and t with negative slope.

$y = ut - \frac{1}{2}gt^2$

All these characteristics are represented by graph (b).

Question240

A particle has an initial velocity of $3\hat{i} + 4\hat{j}$ and an acceleration of $0.4\hat{i} + 0.3\hat{j}$. Its speed after 10 s is:
[2009]

Options:

A. $7\sqrt{2}$ units

B. 7 units

C. 8.5 units

D. 10 units

Answer: A

Solution:

Solution:
Given $\vec{u} = 3\hat{i} + 4\hat{j},\ \vec{a} = 0.4\hat{i} + 0.3\hat{j},\ t = 10s$
From 1 st equatoin of motion.
$a = \frac{v - u}{t}$
$\therefore v = attu$
$\Rightarrow v = \left(0.4\hat{i} + 0.3\hat{j}\right) \times 10 + \left(3\hat{i} + 4\hat{j}\right)$
$\Rightarrow 4\hat{i} + 3\hat{j} + 3\hat{j} + 4\hat{j}$
$\Rightarrow v = 7\hat{i} + 7\hat{j}$
$\Rightarrow |\vec{v}| = \sqrt{7^2 + 7^2} = 7\sqrt{2}$ unit.

Question241

The velocity of a particle is $v = v_0 + gt + f t^2$. If its position is x = 0 at t = 0, then its displacement after unit time (t = 1) is
[2007]

Options:

A. $v_0 + \frac{g}{2} + f$

B. $v_0 + 2g + 3f$

C. $v_0 + \frac{g}{2} + \frac{f}{3}$

D. $v_0 + g + f$

Answer: C

Solution:

Solution:

We know that, $v = \frac{dx}{dt}$

$\Rightarrow dx = v\,dt$

Integrating, $\int_0^x dx = \int_0^t v\,dt$

or $x = \int_0^t (v_0 + gt + ft^2)dt = \left[v_0 t + \frac{gt^2}{2} + \frac{ft^3}{3} \right]_0^t$

or, $x = v_0 t + \frac{gt^2}{2} + \frac{ft^3}{3}$

At $t = 1$, $x = v_0 + \frac{g}{2} + \frac{f}{3}$

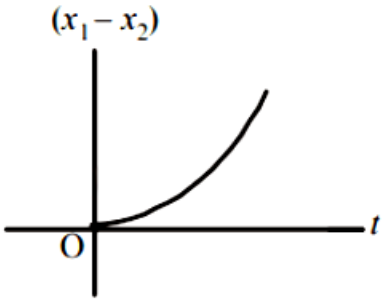
Question242

A body is at rest at x = 0. At t = 0, it starts moving in the positive x - direction with a constant acceleration. At the same instant another body passes through x = 0 moving in the positive x -direction with a constant speed. The position of the first body is given by $x_1(t)$ after time 't'; and that of the second body by $x_2(t)$ after the same time interval. Which of the following graphs correctly describes $(x_1 - x_2)$ as a function of time 't'?

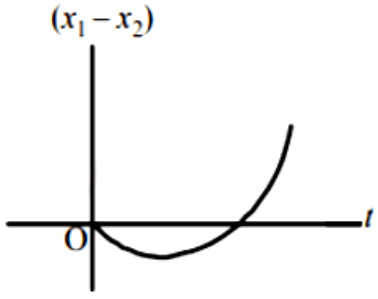
2008

Options:

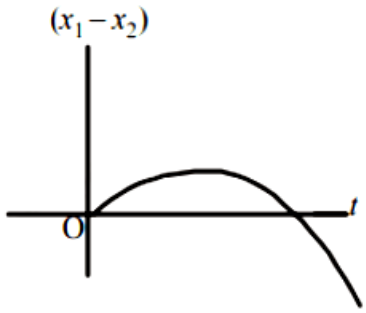
A.



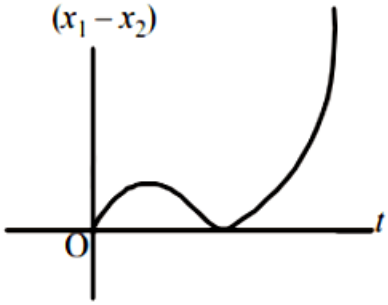
B.



C.



D.



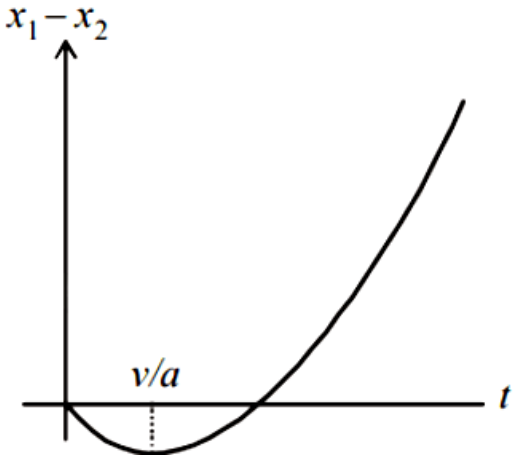
Answer: B

Solution:

Solution:
For the body starting from rest, distance travelled (x_1) is given by

$x_1 = 0 + \frac{1}{2}at^2$

$\Rightarrow x_1 = \frac{1}{2}at^2$



For the body moving with constant speed

$x_2 = vt \therefore x_1 - x_2 = \frac{1}{2}at^2 - vt$

at $t = 0, x_1 - x_2 = 0$

This equation is of parabola.

For $t < \frac{v}{a}$; the slope is negative

For $t = \frac{v}{a}$; the slope is zero

For $t > \frac{v}{a}$; the slope is positive

These characteristics are represented by graph (b).

Question243

A particle located at x = 0 at time t = 0, starts moving along with the positive x-direction with a velocity ' v ' that varies as v = αx . The displacement of the particle varies with time as
[2006]

Options:

A. t^2

B. t

C. $t^{1/2}$

D. t^3

Answer: A

Solution:

Solution:
$v = \alpha\sqrt{x}$
$\Rightarrow \frac{dx}{dt} = \alpha\sqrt{x} \Rightarrow \frac{dx}{\sqrt{x}} = \alpha dt$
Integrating both sides,
$\int_0^x \frac{dx}{\sqrt{x}} = \alpha \int_0^t dt;\ \left[\frac{2\sqrt{x}}{1}\right]_0^x = \alpha[t]_0^t$
$\Rightarrow 2\sqrt{x} = \alpha t \Rightarrow x = \frac{\alpha^2}{4}t^2$

Question244

A car, starting from rest, accelerates at the rate f through a distance S, then continues at constant speed for time t and then decelerates at the rate $\frac{f}{2}$ to come to rest. If the total distance traversed is 15S, then
[2005]

Options:

A. $S = \frac{1}{6}ft^2$

B. $S = ft$

C. $S = \frac{1}{4}ft^2$

D. $S = \frac{1}{72}ft^2$

Answer: D

Solution:

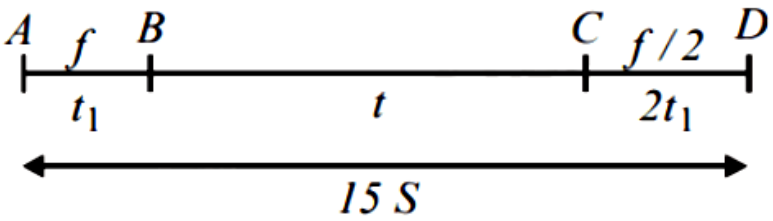
Solution:

Let car starts from A from rest and moves up to point B with acceleration f.

Distance, $AB = S = \frac{1}{2} f t_1^{\,2}$

Distance, $BC = (f t_1)t$

Distance, $CD = \frac{u^2}{2a} = \frac{(f t_1)^2}{2\left(\frac{f}{2}\right)} = f t_1^{\,2} = 2S$



Total distance, AD = AB + BC + CD = 15S

AD = S + BC + 2S

$\Rightarrow S + f t_1 t + 2S = 15S$ .....(i)

$\Rightarrow f t_1 t = 12S$

$\frac{1}{2} f t_1^{\,2} = S$ .....(ii)

Dividing (i) by (ii), we get $t_1 = \frac{t}{6}$

$\Rightarrow S = \frac{1}{2} f \left(\frac{t}{6}\right)^2 = \frac{f t^2}{72}$

Question245

A particle is moving eastwards with a velocity of $5ms^{-1}$. In 10 seconds the velocity changes to $5ms^{-1}$ northwards. The average acceleration in this time is [2005]

Options:

A. $\frac{1}{2} ms^{-2}$ towards north

B. $\frac{1}{\sqrt{2}} ms^{-2}$ towards north - east

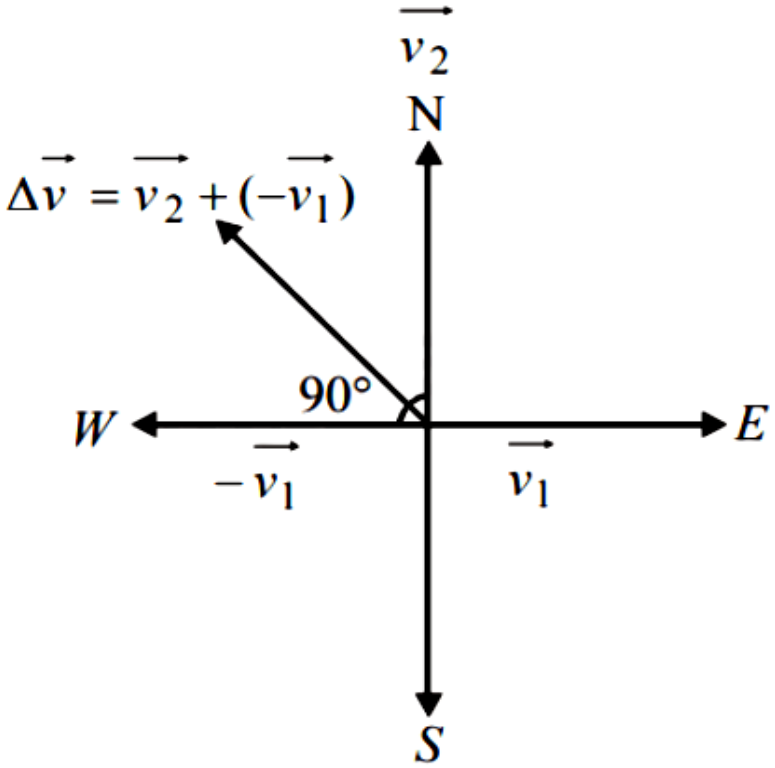
C. $\frac{1}{\sqrt{2}} ms^{-2}$ towards north - west

D. zero

Answer: C

Solution:

Solution:



Initial velocity, $\vec{v}_1 = 5\hat{i}$,

Final velocity, $\vec{v}_2 = 5\hat{j}$,

Change in velocity $\Delta\vec{v} = \left(\vec{v}_2 - \vec{v}_1\right) = \sqrt{v_1^2 + v_2^2 + 2v_1v_2\cos 90°} = \sqrt{5^2 + 5^2 + 0} = 5\sqrt{2}\,m/s$

[As $|v_1| = |v_2| = 5m/s$]

Avg. acceleration $= \frac{\Delta\vec{v}}{t} = \frac{5\sqrt{2}}{10} = \frac{1}{\sqrt{2}}m/s^2$

$\tan\theta = \frac{5}{-5} = -1$

which means θ is in the second quadrant. (towards north-west)

Question246

The relation between time t and distance x is $t = ax^2 + bx$ where a and b are constants. The acceleration is
[2005]

Options:

A. $2bv^3$

B. $-2abv^2$

C. $2av^2$

D. $-2av^3$

Answer: D

Solution:

Solution:
Given, $t = ax^2 + bx$;
Diff. with respect to time (t)
$\frac{d}{dt}(t) = a\frac{d}{dt}(x^2) + b\frac{dx}{dt} = a \cdot 2x\frac{dx}{dt} + b \cdot v.$
$\Rightarrow 1 = 2axv + bv = v(2ax + b)$ (v = velocity)
$2ax + b = \frac{1}{v}$
Again differentiating, we get
$2a\frac{dx}{dt} + 0 = -\frac{1}{v^2}\frac{dv}{dt}$
$\Rightarrow a = \frac{dv}{dt} = -2av^3 \left(\because \frac{dx}{dt} = v\right)$

Question247

A parachutist after bailing out falls 50 m without friction. When parachute opens, it decelerates at 2 m/s^2. He reaches the ground with a speed of 3 m/s. At what height, did he bail out ?
[2005]

Options:

A. 182 m

B. 91 m

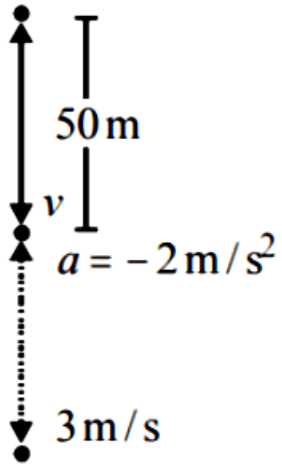
C. 111 m

D. 293 m

Answer: D

Solution:

Solution:



Initial velocity of parachute after bailing out,
$u = \sqrt{2gh}$
$u = \sqrt{2 \times 9.8 \times 50} = 14\sqrt{5}$
The velocity at ground, $v = 3m/s$
$S = \frac{v^2 - u^2}{2 \times 2} = \frac{3^2 - 980}{4} \approx 243m$
Initially he has fallen $50m$.
∴ Total height from where he bailed out $= 243 + 50 = 293m$

Question248

An automobile travelling with a speed of 60 km/h, can brake to stop within a distance of 20m. If the car is going twice as fast i.e., 120 km/h, the stopping distance will be [2004]

Options:

A. 60 m

B. 40 m

C. 20 m

D. 80 m

Answer: D

Solution:

Solution:
In first case speed, $u = 60 \times \frac{5}{18} m/s = \frac{50}{3} m/s$
$d = 20m$
Let retardation be a then
$(0)^2 - u^2 = -2ad$
or $u^2 = 2ad$ ....(i)
In second case speed, $u' = 120 \times \frac{5}{18} = \frac{100}{3} m/s$
and $(0)^2 - u'^2 = -2ad'$
or $u'^2 = 2ad'$ ....(ii)
(ii) divided by (i) gives,
$4 = \frac{d'}{d} \Rightarrow d' = 4 \times 20 = 80m$

Question249

A ball is released from the top of a tower of height h meters. It takes T seconds to reach the ground. What is the position of the ball at $\frac{T}{3}$ second
[2004]

Options:

A. $\frac{8h}{9}$ meters from the ground

B. $\frac{7h}{9}$ meters from the ground

C. $\frac{h}{9}$ meters from the ground

D. $\frac{17h}{18}$ meters from the ground

Answer: A

Solution:

Solution:
We have $s = ut + \frac{1}{2}gt^2$,

$\Rightarrow h = 0 \times T + \frac{1}{2}gT^2$

$\Rightarrow h = \frac{1}{2}gT^2$

Vertical distance moved in time $\frac{T}{3}$ is

$h' = \frac{1}{2}g\left(\frac{T}{3}\right)^2$

$\Rightarrow h' = \frac{1}{2} \times \frac{gT^2}{9} = \frac{h}{9}$

$\therefore$ Position of ball from ground $= h - \frac{h}{9} = \frac{8h}{9}$

Question250

If $\vec{A} \times \vec{B} = \vec{B} \times \vec{A}$, then the angle between A and B is
[2004]

Options:

A. $\frac{\pi}{2}$

B. $\frac{\pi}{3}$

C. π

D. $\frac{\pi}{4}$

Answer: C

Solution:

Solution:
$\vec{A} \times \vec{B} - \vec{B} \times \vec{A}$
$\Rightarrow \vec{A} \times \vec{B} + \vec{A} \times \vec{B} = 0$
$\therefore \vec{A} \times \vec{B} = 0$
Angle between them is $0, \pi$, or 2π
from the given options, $\theta = \pi$

Question251

A projectile can have the same range ' R ' for two angles of projection. If ' T_1 ' and ' T_2 ' to be time of flights in the two cases, then the product of the two time of flights is directly proportional to.
[2004]

Options:

A. R

B. $\frac{1}{R}$

C. $\frac{1}{R^2}$

D. R^2

Answer: A

Solution:

Solution:
A projectile have same range for two angle
Let one angle be θ, then other is $90° - \theta$
$T_1 = \frac{2u \sin\theta}{g}, T_2 = \frac{2u \cos\theta}{g}$
then, $T_1 T_2 = \frac{4u^2 \sin\theta \cos\theta}{g} = 2R$
$\left(\because R = \frac{u^2 \sin^2\theta}{g}\right)$
Thus, it is proportional to R. (Range)

Question252

A ball is thrown from a point with a speed ' v_0 ' at an elevation angle of θ. From the same point and at the same instant, a person starts running with a constant speed $\frac{'v_0'}{2}$ to catch the ball. Will the person be able to catch the ball? If yes, what should be the angle of projection θ?
[2004]

Options:

A. No

B. Yes, 30°

C. Yes, 60°

D. Yes, 45°

Answer: C

Solution:

Solution:
Yes, Man will catch the ball, if the horizontal component of velocity becomes equal to the constant speed of man.
$\frac{v_o}{2} = v_o \cos\theta$
or $\theta = 60°$

Question253

A car, moving with a speed of 50 km/hr, can be stopped by brakes after at least 6 m. If the same car is moving at a speed of 100 km/hr, the minimum stopping distance is [2003]

Options:

A. 12 m

B. 18 m

C. 24 m

D. 6 m

Answer: C

Solution:

Solution:
Fir first case : Initial velocity,
$u = 50 \times \frac{5}{18} m/s$
$v = 0, s = 6m, a = a$
Using, $v^2 - u^2 = 2as$
$\Rightarrow 0^2 - \left(50 \times \frac{5}{18}\right)^2 = 2 \times a \times 6$
$\Rightarrow -\left(50 \times \frac{5}{18}\right)^2 = 2 \times a \times 6$
$a = -\frac{250 \times 250}{324 \times 2 \times 6} \approx = -16 ms^{-2}$
Case-2 : Initial velocity, u = 100 km/hr $= 100 \times \frac{5}{18} m/sec$
$v = 0, s = s, a = a$
As $v^2 - u^2 = 2as$
$\Rightarrow 0^2 - \left(100 \times \frac{5}{18}\right)^2 = 2as$

$\Rightarrow -\left(100 \times \frac{5}{18}\right)^2 = 2 \times (-16) \times 5$

$s = \frac{500 \times 500}{324 \times 32} = 24\text{m}$

Question254

The co-ordinates of a moving particle at any time ' t 'are given by $x = \alpha t^3$ and $y = \beta t^3$. The speed of the particle at time ' t ' is given by [2003]

Options:

A. $3t\sqrt{\alpha^2 + \beta^2}$

B. $3t^2\sqrt{\alpha^2 + \beta^2}$

C. $t^2\sqrt{\alpha^2 + \beta^2}$

D. $\sqrt{\alpha^2 + \beta^2}$

Answer: B

Solution:

Solution:
Coordinates of moving particle at time ' t ' are $x = \alpha t^3$ and $y = \beta t^3$

$v_x = \frac{dx}{dt} = 3\alpha t^2$ and $v_y = \frac{dy}{dt} = 3\beta t^2$

$\therefore v = \sqrt{v_x^2 + v_y^2} = \sqrt{9\alpha^2 t^4 + 9\beta^2 t^4}$

$= 3t^2\sqrt{\alpha^2 + \beta^2}$

Question255

A boy playing on the roof of a 10 m high building throws a ball with a speed of 10m/s at an angle of 30º with the horizontal. How far from the throwing point will the ball be at the height of 10 m from the ground ?

$\left[\mathbf{g = 10m/s^2,\ \sin 30° = \frac{1}{2},\ \cos 30° = \frac{\sqrt{3}}{2}}\right]$

[2003]

Options:

A. 5.20m

B. 4.33m

C. 2.60m

D. 8.66m

Answer: D

Solution:

Solution:
Horizontal range is required

$$R = \frac{u^2 \sin 2\theta}{g} = \frac{(10)^2 \sin(2 \times 30°)}{10} = 5\sqrt{3} = 8.66\text{m}$$

Question256

If a body looses half of its velocity on penetrating 3 cm in a wooden block, then how much will it penetrate more before coming to rest?
[2002]

Options:

A. 1 cm

B. 2 cm

C. 3 cm

D. 4 cm

Answer: A

Solution:

Solution:
In first case

$u_1 = u;\ v_1 = \frac{u}{2},\ s_1 = 3\text{ cm},\ a_1 = ?$

Using, $v_1^2 - u_1^2 = 2a_1 s_1$

$\left(\frac{u}{2}\right)^2 - u^2 = 2 \times a \times 3$

$\Rightarrow a = \frac{-u^2}{8}$

In second case: Assuming the same retardation

$u_2 = \frac{u}{2};\ v_2 = 0;\ s_2 = ?;\ a_2 = \frac{-u^2}{8}$

$v_2^2 - u_2^2 = 2a_2 \times s_2$

$\therefore 0 - \frac{u^2}{4} = 2\left(\frac{-u^2}{8}\right) \times s_2$

$\Rightarrow s_2 = 1\text{ cm}$

Question257

Speeds of two identical cars are u and 4u at the specific instant. The ratio of the respective distances in which the two cars are stopped from that instant is
[2002]

Options:

A. 1 : 1

B. 1 : 4

C. 1 : 8

D. 1 : 16

Answer: D

Solution:

Solution:
For first car
$u_1 = u, v_1 = 0, a_1 = -a, s_1 = s_1$
As $v_1^2 - u_1^2 = 2a_1s_1$
$\Rightarrow -u^2 = -2as_1$
$\Rightarrow u^2 = 2as_1$
$\Rightarrow s_1 = \frac{u^2}{2a}$ ...(i)
For second car
$u_2 = 4u, v_1 = 0, a_2 = -a, s_2 = s_2$
$\therefore v_2^2 - u_2^2 = 2a_2s_2$
$\Rightarrow -(4u)^2 = 2(-a)s_2$
$\Rightarrow 16u^2 = 2as_2$
$\Rightarrow s_2 = \frac{8u^2}{a}$
Dividing (i) and (ii),
$\frac{s_1}{s_2} = \frac{u^2}{2a} \cdot \frac{a}{8u^2} = \frac{1}{16}$

Question258

From a building two balls A and B are thrown such that A is thrown upwards and B downwards (both vertically). If v_A and v_B are their respective velocities on reaching the ground, then
[2002]

Options:

A. $v_B > v_A$

B. $v_A = v_B$

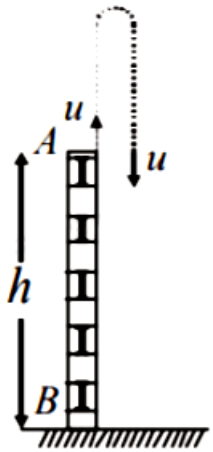
C. $v_A > v_B$

D. their velocities depend on their masses.

Answer: B

Solution:

Solution:



Ball A is thrown upwards with velocity u from the building. During its downward journey when it comes back to the point of throw, its speed is equal to the speed of throw (u).
So, for the journey of both the balls from point A to B.
We can apply $v^2 - u^2 = 2gh$.
As u, g, h are same for both the balls, $v_A = v_B$